New Movie: Dogfights and Daring

Hot Air Balloons in Space –Really PAGE 58

AIR&SPACE Smithsonian

# THE KING OF CLIMB

Douglas F4D Skyray >>>

[ THE BIG ISSUE ]

* Biggest Helicopter
* Biggest Airliner
* Biggest Radar

## Glenn Curtiss Gets No Respect

## *How Many Cessnas Does It Take to Win "Best Selling Airplane"?*

FIND OUT ON PAGE 20

JULY 2006

# We apologize that it loses 1 second every 20 million years…

*The classic watch built with German precision to 1 billionth of a second?*

There is a new super-accurate government device that gives you a perfect use for atomic theory. The US government has engineered the most ingenious, most accurate clock in the world, the new F-1 U.S. Atomic Clock in Boulder, Colorado. Our extraordinary new Stauer EMC² watch uses this clock to report the exact time from this remarkable cesium fission clock. So you are on time…all the time. This amazing clock will gain or lose only one second over a twenty million-year period. It is that accurate!

***This perfectly tuned technological invention is now available for UNDER $100.*** And you'll never have to set this watch…the hands set themselves. Just push one of the buttons and you are synchronized with the F-1 and the hands of the watch move to the exact time position. The Stauer EMC² exceeds the accuracy of any Swiss luxury automatic so you can be more accurate and keep most of your money in your wallet… not on your wrist.

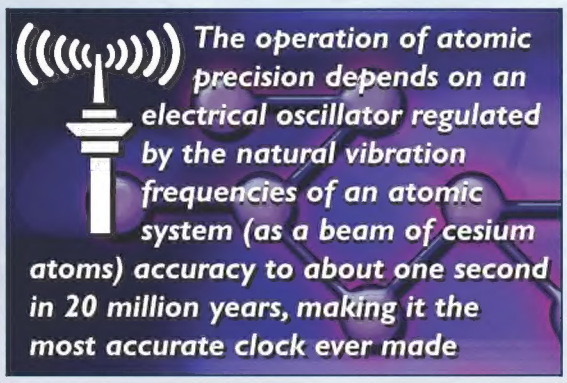
There are some unattractive plastic digital atomic watches on the market, but when our German movement maker made it possible for us to break the $100 price barrier with a beautiful, classically styled stainless steel analog watch, we were truly excited.

The EMC² features precise atomic time with an automatic Standard time and Daylight Saving Time adjustment. It will adjust for leap years and even leap seconds! A breakthrough in technology at a breakthrough price.

The large numeric markers are luminescent and extremely easy to read so the watch is perfect for low light situation. The EMC² is water-resistant to 5 atms as well. The small readout shows you the date and has a digital second counter. This watch is rugged enough to take to the gym but handsome enough to wear to the boardroom or out to dinner. The designers built this watch for those who prefer their watches to be practical and sharp-looking rather than overrated and overpriced.

***How can it be so accurate?*** The new F-1 clock uses laser beams to measure the photons emitted from the cesium atom to measure the resonance frequency. This laser-cooling clock makes it about 20 times more accurate than any other clock on earth.

This timepiece is a great gift for anyone who values precision and technology. Know precisely when the markets open and close. Know the times for landings and take offs or when the train is leaving the station. If punctuality and accuracy matter, then this watch was built for you.




***We're still perfecting atomic theory.*** We must apologize that our Stauer EMC² Atomic Watch loses 1 second every 20,000,000 years. Our scientists are working diligently to correct this problem; but in the interim if you are not thrilled with the design and the accuracy of the EMC², return it in the next 30 days for a full refund of the purchase price.

This watch is not available in stores and it comes with our 30 day money-back guarantee. If you're not completely satisfied with the accuracy, simply return the watch for the full purchase price.

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**Canon**

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# Six Decades of Progress

The National Air and Space Museum has a tradition of recognizing anniversaries, and 2006 provides three chances to celebrate. Sixty years ago, on February 13, 1946, President Truman signed Public Law 722, establishing the National Air Museum as a separate bureau of the Smithsonian Institution. Twenty years later, in 1966, President Johnson asked Congress to add the field of spaceflight to our mission and title. After one more decade, in July 1976, we opened the doors of the National Air and Space Museum to the public. And the rest is history. By the end of the first year, we had become the world's most visited museum—a distinction we still enjoy.

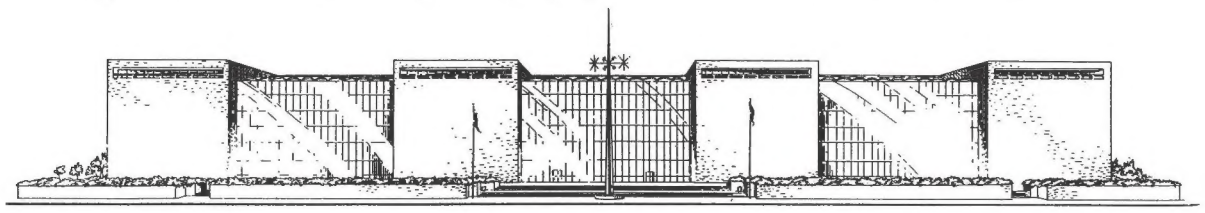
During our triple anniversary year, we will mark high points in our history while sharing news of a future filled with promise. Since we opened the Steven F. Udvar-Hazy Center in 2003, we have welcomed more than three million visitors to the Virginia facility. We have steadily added artifacts to both the James S. McDonnell Space Hangar and the aviation hangar, which, as of April 10, has a new name. Calling it the Boeing Aviation Hangar is our way of thanking and honoring the Boeing Company for its most recent, magnificent donation of $15 million, bringing the company's total contribution to $22 million. This is the largest single corporate gift ever presented to the Smithsonian Institution.

The gift will help fund the project that will carry us into the next decade. Phase Two of the Udvar-Hazy Center will include an archives research facility, where the gems of the Museum's photography and document collections will reside, the Emil Buehler Conservation Lab, and a state-of-the-art Restoration hangar. Featuring overlooks for public viewing, the hangar will accommodate audiences gathered to watch specialists at work preserving historic aircraft and spacecraft.

Until the new hangar is completed, artifacts will continue to be restored at the Paul E. Garber facility in Maryland. Over the decades, this no-frills workplace has been the scene of hundreds of transformations: old and broken machines brought to life by talented, dedicated professionals. The latest miracle is the Northrop P-61 Black Widow, one of only three known to exist. The aircraft will be placed on display at the Udvar-Hazy Center this month (see In the Museum, p. 14).

When the Mall building turns 30 in July, we will share "Museum memories" and birthday cake with visitors, in conjunction with our annual "Mars Day!" celebration. At the opening of the Mall building, one of the high points of America's Bicentennial, President Gerald Ford called the Museum "a perfect birthday present from the American people to themselves." President Ford's words inspire us every time the Museum celebrates an anniversary. Since 1976, we have welcomed more than 250 million people to enjoy this wonderful gift. Fulfilling our commitment to commemorate the history of aerospace and educate and inspire people about the science and technology of flight is as relevant in the 21st century as it was 30, 40, and 60 years ago.

J.R. DAILEY IS THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.





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EDITORIAL: (202) 275-1230
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***Air & Space/Smithsonian*** (ISSN 0886-2257) is published bimonthly by Smithsonian Business Ventures, MRC 951, P.O. Box 37012, Washington, DC 20013.  Editorial offices: MRC 951, P.O. Box 37012, Washington, DC 20013. Circulation and advertising offices: 420 Lexington Ave., New York, NY 10170. Canadian publication agreement no. 40039324. Canadian return address: 7496 Bath Road, Unit 2, Mississauga, ON L4T 1L2.

**Subscription Prices:** U.S. and possessions: $24 a year payable in U.S. funds. Canada and all other countries: add $6.00 (U.S. funds) per year. Eighty-five percent of dues is designated for magazine subscription. Current issue price: $3.99 (U.S. funds). Back issue price: $7.00 (U.S. funds). Periodical postage paid at Washington, DC, and additional mailing offices.

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# LETTERS

## I Know That Plane!

I was surprised to see a picture of a pair of F-100 Super Sabres about to engage a target in South Vietnam ("The Century Series," Dec. 2005/Jan. 2006). I immediately identified one of the aircraft as being based at Phu Cat air base. My wife doubted me, so I dug into my archives and pulled out a photo of my load crew and I (back in 1968) loading 750-pound bombs on one of Phu Cat's F-100Ds, and the photo showed that the plane had the same tail letters as the one in your painting: HE 907.

Phu Cat's F-100s were used extensively in support of ground troops in the South and in clearing "the Trail." It was not unusual for our alert birds to fly six or seven times a day.

What makes the painting so memorable for me is not that the jet came from my base in Vietnam, but that after being a weapons mechanic for five years, I joined the officer ranks and eventually ended up flying—you guessed it—the F-100, and then the A-10, for almost 20 years. Currently I fly as an MD-11 captain. Just last month I was flying over Vietnam, talking to Ho Chi Minh Control. The world's getting smaller every day.

STEVE MELTSNER
COLONEL, U.S. AIR FORCE (RET.)
WEST HARTFORD, CONNECTICUT

## Short Story

I did not build my Stits Sky Baby SA-2 to have it claimed "world's smallest" by the *Guinness Book of World Records*, as your article "Think Small" (Apr./May 2006) stated. I built Sky Baby to replace my 1948 Stits Junior, an eight-foot, 10-inch monoplane I developed as a "smallest airplane" airshow act; the Stits Junior was damaged in an off-airport landing in 1951. I built the Sky Baby in the early 1950s and didn't hear of the Guinness book until the late 1950s.

A major distinction that aviation writers have missed is that there is a significant difference between a small airplane that flies repeatedly, and contenders that on their first flight attempt lift off out of ground effect and crash, then claim a record for the Guinness book.

The Guinness editors were wise to eliminate the "smallest airplane" category to help prevent pilots from getting seriously injured or killed while trying to get a stubby-wing missile just high enough off the runway to be photographed.

RAY STITS
RIVERSIDE, CALIFORNIA

## The Greek Theater

Mark Bernstein says that no Allies were in Europe from June 1940 to September 1943. In fact, Greece was attacked by the Italians on October 28, 1940, and by the Germans on April 6, 1941, and as a result, the Royal Air Force was in Greece from November 1, 1940, until late April 1941.

ROBIN HIGHAM
PROFESSOR EMERITUS, MILITARY HISTORY
KANSAS STATE UNIVERSITY, MANHATTAN

## Beyond the Wrights

Bettina H. Chavanne captured very well La Ferté Alais ("Le Airshow," Apr./May 2006) and the romantic years of early aviation that the show celebrates. However, she was not very precise in referring to Alberto Santos-Dumont as French. Though Santos-Dumont had been living in France since he was 18, in Brazil we are very proud of the fact that a man who played an important part in the development of the airplane was Brazilian.

It would also have been nice if the article had explained the differences between the Americans and the Europeans in the ways they pioneered aviation. For example, while the former looked for ways to economically exploit their hard efforts, the latter (in general) believed that they were contributing to the advancement of humankind.

LUIZ DE OLIVEIRA
PARIS, FRANCE



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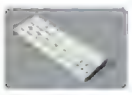

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## Two Bells, One Ike

"No Runway Required" (Viewport, Apr./May 2006) refers to a Bell H-13J helicopter purchased in 1957 for the use of President Eisenhower. If my memory is accurate, not one but two identical J models were purchased. Conjecture around the plant was that authorities wanted them both in the air at the same time. That way, a potential enemy would not be sure which one contained the president.

AL MURDOCK
DENTON, TEXAS

## Not Rooting for Rutan

"Go Ballistic" (Feb./Mar. 2006) left me scratching my head. Burt Rutan's SpaceShipOne was a great technological success, but I for one am not jumping up and down for joy. It seems as if the only goal for this technology now is roller coaster rides for the rich and famous. Everyone talks about NASA and the government wasting money on the space shuttle and the space station. That may be true, but at least some science is going on there.

I heard Burt Rutan say that a vehicle similar to SpaceShipOne would need about 30 times more energy to attain orbit. I think that should be the next goal for the X-Prize. Call it X-Prize Part II or whatever: Orbit a manned vehicle and reenter the atmosphere to a safe landing. And repeat the adventure. That's obviously a much more difficult and expensive goal to attain for a small private outfit.

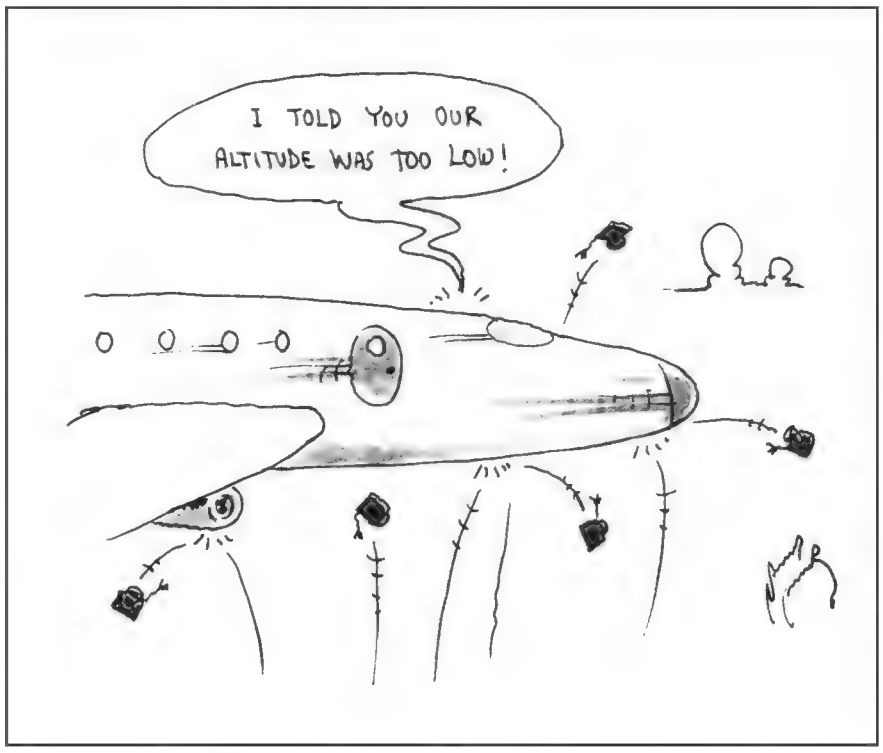
CHRISTOPHER C. BLACK
GRAPEVINE, TEXAS

## Relics? Hardly

I take issue with the last sentence in "By Stars, Beacons, and Satellites" (Feb./Mar. 2006), which says that all forms of navigation aside from GPS are relics. As a current airline pilot and former flight instructor, I often had to justify to students why NDBs (non-directional beacons), VORs (very-high-frequency omnidirectional range), and pilotage/dead reckoning are skills they need to have and on which they are tested.

Because the GPS box could fail, or the aircraft could suffer an electrical failure, any good pilot should have the skills to get from point A to point B without GPS.

MIKE NIEBUHR
ATLANTA, GEORGIA




## The PV Fraternity

Having read "Fire and Ice," on the PV-1 Venturas (Feb./Mar. 2006), our group was most impressed by the question posed in one of the last paragraphs: "The mystery is solved, but a larger question remains: Why these men emerged from World War II with so little recognition."

We're asking the same question. I am the president of the non-profit American Military Heritage Foundation, which operates the only flying PV-2 Harpoon in military configuration in the world, and it was our aircraft and flight crew that doubled for the PV-1 in the 2003 PBS documentary "The Last Flight of Bomber 31." Our mission is to preserve this aircraft and to memorialize those who flew or maintained PV-1s and -2s.

Our first appearance this year will be over the Memorial Day weekend at the Tullahoma, Tennessee airshow, and we expect to be giving rides to the public by sometime this summer. We are seeking veterans who were affiliated with the PV-1 Ventura or the PV-2 Harpoon for our oral history project. Our contact information is below.

DOUG CROSS
E-MAIL: PRESIDENT@AMHF.ORG
WEB SITE: AMHF.ORG
PHONE: (317) 883-4721

## Corrections

*Apr./May 2006* "Son of Apollo": The new moon vehicle's ascent stage will not use liquid hydrogen and liquid oxygen propellants but rather hydrazine and nitrogen tetroxide, the fuels used for the Apollo lunar module.

"Airshows 2006": The dates for the Little Rock, Arkansas Air Force Base Open House should be November 4 and 5, not October 28 and 29.

The dates for the Blue Angels Homecoming at Naval Air Station Pensacola, Florida, should be November 10 and 11, not November 4 and 5.

*Write to us at Letters,* Air & Space/ Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012. Please type or print clearly. You must include your full address and your daytime phone number.*

*Note our new e-mail address:* editors@si.edu. *You must include your full name, mailing address, and daytime phone number.*

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*All letters selected for publication are edited. We regret that we cannot respond to every letter.*

*To some, sunglasses are a fashion accessory…*

# But When Driving, These Sunglasses May Save Your Life!

Drivers Alert: ***Driving can expose you to more dangerous glare than any sunny summer day at the beach can…do you know how to protect yourself?***

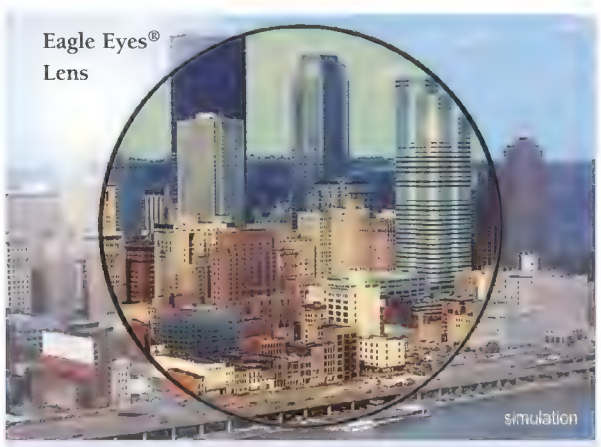
An amazing breakthrough in optic technology by NASA resulting in Eagle Eyes® can be your answer. The sun rises and sets at peak travel periods, during the early morning and afternoon rush hours. Many drivers find themselves temporarily blinded as they are driving directly into the glare of the sun. Deadly accidents are regularly caused by such blinding glare. Danger can come from reflected light off of another vehicle, from the pavement, or any other reflective surface. Early morning frost or dew can exacerbate this situation. Salted or snowy road conditions can make matters even worse. Yet, motorists struggle on despite being blinded by the sun's glare and cause countless accidents every year.

## Beware of windshield glare!

This glare-induced "blindness" is especially prevalent in the early morning or late in the afternoon, and due to the extremely reflective qualities of other cars. Even your windshield can make matters worse since wax and oil buildup can increase reflected glare. This powerful glare of the sun is damaging to the various layers of the eye. Certain road conditions may raise the amount of harmful UV that you are exposed to by 85%.

## NASA's researchers looked to nature for a solution.

Conventional sunglasses can in fact blur your vision by exposing your eye to harmful

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*As a board certified ophthalmologist, I recommend Eagle Eyes® to all my patients to protect and enhance their vision!*

*—Dr. Lyda D. Tymiak*

UV, blue light rays, and reflective glare. They can also darken useful vision-enhancing light. At NASA's Jet Propulsion Laboratory, scientists looked to nature for a solution by studying the eyes of eagles, known for their extreme visual acuity. The result of this breakthrough optical technology is Eagle Eyes®. NASA's researchers studied how eagles can simultaneously distinguish their prey from their surroundings with utmost precision, while protecting their eyes from the daily exposure of harmful high-energy sunlight. These studies led to this revolutionary protection for human eyesight.

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# The Atlas Family

COURTESY DAN SCHMIDT/NASA

COURTESY CAL FOWLER/NASA

**The object of their affections: Surveyor B, in the nose fairing, is readied for an Atlas booster (left); a Mercury Atlas 1 in the test stand, flanked by test conductors (below)—today's Rickety Rocketeers.**

ON THE FOURTH THURSDAY of every odd-numbered month, the men—and a woman or two—who launched Atlas rockets at Cape Canaveral, Florida, in the early days of the Space Age gather for breakfast to swap off-color jokes and to gab about God, country, and old times.

"We welcome anyone who has ever worked on the Atlas," says Dan Schmidt, a retired systems engineer who publishes the Rickety Rocketeers' newsletter. There are bosses, secretaries, engineers, mechanics, quality inspectors, technicians, and launch conductors. The only membership requirement is to have drawn a paycheck from a company associated with launching what this group considers the Cadillac of missiles.

Most worked for General Dynamics Space Systems, the original builder of Atlas, from the late 1950s into the 1970s. They launched the first successful test of an intercontinental ballistic missile, put the first Americans into Earth orbit, and dispatched the first probe to land softly on the moon. The first launch vehicle that actually reached orbit was an Atlas, and the communications satellite it carried broadcast President Eisenhower's Christmas message to the world in 1958. Interplanetary spacecraft that gave humans their first glimpses of Mars and Venus—and some that left the solar system—left this planet atop Atlas rockets.

The group has been meeting regularly for at least 10 years. From a nucleus of four retirees, the roster has grown to 374. About 90 filled a hotel banquet room in March. After a short "business" meeting with updates on who was sick and who had passed on, the reminiscing began. "If you wrote everything that's happened out there, you'd have to label it fiction, 'cause nobody'd believe it," says Joe Kadlec, who worked at the Cape from 1957 until 1996.

Some toted scrapbooks and other memorabilia to show a reporter. Eighty-two-year-old Bill McClure had the framed citation that accompanied his medal from NASA for exceptional bravery, which he was awarded in 1969 for risking his life to avert a catastrophe at Launch Complex 36A. It happened in February that year, 10 days before Mariner 6 was sent to Mars on an Atlas. McClure and buddy Jack Beverlin were gearing up for a pre-launch fueling test when engine valves suddenly opened wide, relieving pressure that kept the 12-story booster erect. (The Atlas propellant tanks had such thin walls that the booster's structural integrity was maintained by internal pressure.) The opening of the valves sounded like an explosion. "The missile was deflating through the engine valves," recalls McClure. The valves were at three levels inside the Atlas, which was beginning to crumple. Off in the distance, Schmidt heard the blockhouse monitor on 36B issuing pages: "Clear 36A tower. 36A tower. Atlas propulsion Channel 2." Schmidt saw the vehicle moving and people scattering.

McClure and Beverlin managed to close some valves manually. In about 90 seconds the crisis was over, but the dam-

UPDATE

## Looking for a Few Good Insects

The Defense Advanced Research Projects Agency is trolling for proposals to turn cyborg insects into inexpensive "micro air vehicle sensor platforms" with which to reconnoiter buildings and caves ("Microspies," Apr./May 2000). The agency foresees inserting micro-electromechanical systems into young insects for integration with the insects' biological functions as they develop.

age had been done. The Centaur upper stage was bent over and resting on the upper decks. The launch team hauled in a new rocket, put the spacecraft on top of it, and managed to get Mariner 6 off the ground on time. General Dynamics rewarded McClure and Beverlin with $1,000 savings bonds.

Some Rocketeers went on to key positions in the Apollo and space shuttle programs; some stayed with Atlas/Centaur for the rest of their careers. The new Atlas launchers would hardly be recognizable to the personnel who worked with the early rockets. With a rigid structure and engines made in Russia, the Atlas V is still launched from Cape Canaveral Air Force Station, but today the partnership conducting the launches consists of Lockheed Martin and the Khrunichev State Research and Production Center.

BETH DICKEY

## A Moving Target

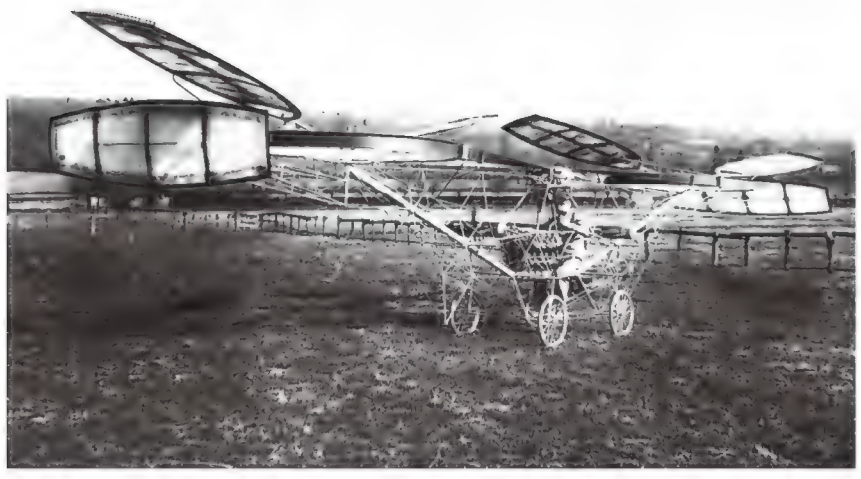
Thundering herds of airplane enthusiasts gathered in North Carolina for the December 17, 2003 centennial of the Wright *Flyer*'s first flight. With November 13, 2007, heralding the 100th anniversary of the first helicopter flight, where's the parade? Hold on.

Aiming for the Archdeacon prize (50,000 francs for the first one-kilometer powered flight), Paul Le Cornu reportedly hovered for about 20 seconds in his twin-rotor helicopter on November 13 in Lisieux, France. But according to Roger Connor, co-chair of the American Helicopter Society's history committee and curator at the National Air and Space Museum, Le Cornu's aerial triumph is not as clear-cut as the Wright brothers' documented first. Connor notes that the inventor secured few witnesses and no inflight photo. And with its belt drive whirling what amounted to a set of gigantic, bladed bicycle wheels, a recent engineering analysis concluded the craft itself was decidedly "flight-challenged."

As Connor relates it, more than a few of the earliest vertical "flights" actually benefited from steadying ropes, fortuitous gusts, or hoists from helpful bystanders.

Instead of a single "first," Connor proposes a timeline of attempts. Yuriev (1911), Petroczy (1918), d'Ascanio (1928)—not exactly household names. And their machines were monstrosities. Giant egg-beaters (Breguet, 1907), eight sets of stacked biplane blades (Pescara, 1922), even the occasional overhead balloon for balance (Oehmichen, 1920s). The nicknames tell the tale: Georges de Bothezat's multi-ton, multi-rotor Flying Octopus (1923) only sometimes did.

Connor credits the added technical complexity of rotary flight for the delay. "Requirements for more powerful engines and both collective and cyclic pitch controls were too demanding for one inventor," he explains. "They required advances in both technology and funding,



NASM (SI NEG. #74-8533)

**First successful helicopter flight? It's doubtful. Paul Le Cornu's claim of a 20-second hover in his twin-rotor flight-challenged contraption has no in-flight photo and few witnesses to back it up, says a rotary-wing-flight historian.**

END OF THE LINE

## Take a Bow

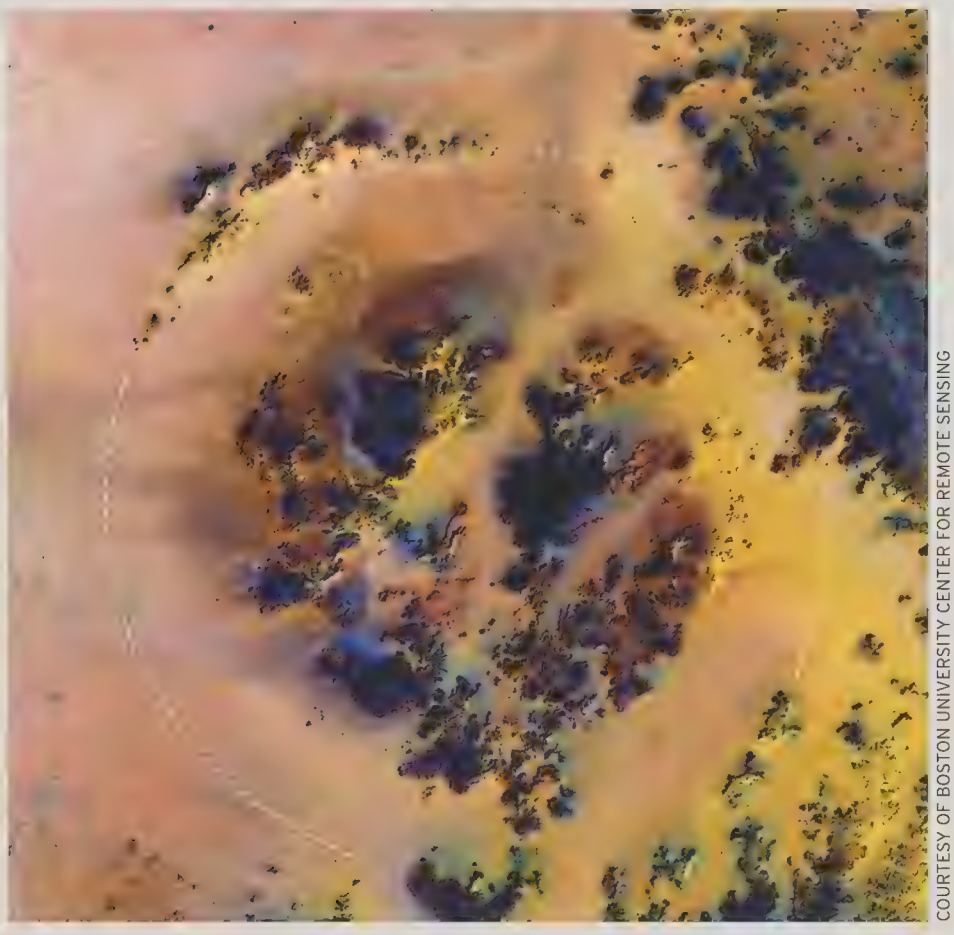
The British Royal Navy has retired the Sea Harrier FA2 fighter, made famous by its involvement in the 1982 Falklands campaign, during which it operated from aircraft carriers in the south Atlantic and downed 15 Argentine aircraft. The last operational Sea Harrier unit, 801 Naval Air Squadron, flew into the history books last March, following sister unit 800NAS by decommissioning the last of the Sea Harriers. Both are to be re-formed as ground attack Harrier GR9 squadrons.

The Hawker Siddeley-designed Sea Harrier FRS1 made its maiden flight in August 1978, and received a comprehensive mid-life upgrade in the 1990s with the potent Blue Vixen advanced pulse-doppler radar; it was the first non-U.S. aircraft to be equipped with the AIM-120 Slammer advanced medium-range air-to-air missile. India remains the only operator of the Sea Harrier and may acquire some of the later United Kingdom examples as they are removed from service.

JAMIE HUNTER

JAMIE HUNTER/AVIACOM

**"You wanna piece of me?" A Sea Harrier that does not seem anxious to retire.**



COURTESY OF BOSTON UNIVERSITY CENTER FOR REMOTE SENSING

UPDATE

## A Big Hole in the Desert

Researchers have discovered a 19-mile-wide asteroid impact crater in the Sahara desert in southwestern Egypt ("Crater Face," Apr./May 2004). The Kebira crater dwarfs Arizona's Meteor Crater, which is about three-quarters of a mile across—the size of the object that created the Saharan crater, says its discoverers, Farouk El-Baz and Eman Ghoneim of Boston University, who discerned the crater in images from satellites.

not available until near mid-century." Helicopter development even needed Juan de la Cierva's 1920s autogyro, with an unpowered rotor dubbed "the Spanish Windmill."

Unlike Kitty Hawk, helicopter milestones elude convenient sound bites or tidy display in a museum case. Controversies about who flew first, often resulting in lively debates among fixed-wing historians, seem to draw far less passion from rotary fans. So if you're set on celebrating a rotary-wing centennial, go ahead and start next year. Just be prepared to party for a really long time.

NICK D'ALTO

## Boeing's Team Moscow

Five p.m. in Moscow is six in the morning in Everett, Washington. But Tom Cogan, chief project engineer for Boeing's forthcoming 787 airliner, never misses the daily video-conference at that hour, even if it means logging on in his pajamas. Cogan has to keep up with the changes Alex Yermonsky's crew made to the aircraft's nose while he was sleeping.

The 787 is Boeing's first global design project, drawing on engineering talent in Japan, Australia, and Italy. But the biggest overseas contributor is Boeing Moscow, whose 1,200 engineers sprawl over nine floors of a hastily refurbished office building 300 yards or so from Red Square. Yermonsky, a Russian engineer hired by Boeing in 1994, commands a team of 350 dedicated to the 787, hacking away at Katiya design software in two shifts spanning 16 hours to reach the optimal compromise in the eternal war between airframe weight and strength.

When the members of Yermonsky's crew finish at 11 p.m. Moscow time, they pass their work to Winnipeg, Ontario, giving their Canadian colleagues most of the afternoon to add their modifications. This round-the-clock regime should slice construction to six years from the seven it took predecessor 777 to go from drawing board to the sky. But Cogan insists the main benefit is more ideas, not more speed.

"The Russians have very good materials technology capability," Cogan says, a compliment that, for a chief project engineer, is downright effusive. "They have a lot of creativity around aircraft structure." In particular, aircraft structure that involves titanium, the temperamental yet irreplaceable metal that is as strong as steel but 40 percent less dense. The Soviets built the world's largest titanium mill in Verkhnaya Salda, a town deep in the Ural Mountains. Now privatized under the name VSMPO, the plant has been named Boeing's "strategic supplier for civil aviation" worldwide. And adapting titanium alloys to next-generation aircraft is key to what the Moscow engineers do 16 hours a day.

Building all this cooperation was not easy, says Sergei Kravchenko, Boeing's employee Number 1 in Russia in 1992 and now chief of operations. The U.S. Department of Commerce took three years to license VSMPO as a metals supplier to American-assembled aircraft, and two years before it would allow Russian 787 engineers to work with advanced materials subject

## The Big Picture

Drivers on Highway 526, which parallels the Boeing factory in Everett, Washington, are getting an eyeful. The airliner maker has spruced up the world's largest building (by volume) with the world's largest digital graphic mural (both superlatives have been bestowed by Guinness World Records). The mural stretches across the south side of the building in which the 747, 767, and 777 are produced and takes up 100,000 square feet. Hey, keep your eyes on the road.

## A. Scott Crossfield

*1921–2006*

Test pilot and aeronautical engineer extraordinaire Scott Crossfield, 84, was killed last April when the twin-engine Cessna 210A he was flying from Maxwell Air Force Base in Alabama to his home in northern Virginia went down in a Georgia thunderstorm.

A Navy fighter pilot and flight instructor, Crossfield was hired by the National Advisory Committee for Aeronautics, the NASA predecessor during the golden age of experimental aircraft, and was sent to Edwards Air Force Base in California to fly cutting-edge X-planes, among them the Bell X-1, Northrop X-4, Douglas D-558-1, Convair XF-92A, and Bell X-5. Flying the D-558-2 in 1953, Crossfield became the first person to fly at twice the speed of sound. Two years later, smitten with the X-15, he left the NACA for the X-15's builder, North American.

NASA DRYDEN

**November 1953: Crossfield and the D-558-2 go Mach 2.**

When the X-15 he was flying in November 1959 suffered an engine fire and he made a forced landing, he recounted in *Always Another Dawn—The Story of a Rocket Test Pilot*: "Quickly I scambled out of the cockpit. What I saw almost broke my heart. The fuselage had buckled immediately aft of the cockpit.... One of the firemen, an old friend who had probably met me on the lake[bed] in his truck a hundred and fifty times, cried quietly as he sprayed the broken plane with water. I felt like crying myself."

Crossfield was portrayed by actor Scott Wilson in the film *The Right Stuff*, which was based on the book by Tom Wolfe that catapulted Crossfield's fellow test pilot Chuck Yeager to international fame. In the film, the X-15 shakes violently as it approaches Mach 2, and Crossfield told a reporter that was wildly inaccurate. Always an engineer at heart, he added, "I will not endorse anything that was in *The Right Stuff*."

Crossfield's most recent test flight project was overseeing the flight testing of a Wright *Flyer* reproduction—he told a TV interviewer that the Wright brothers were his role models—and the training of its pilots for the Kitty Hawk, North Carolina centennial of flight celebration in December 2003.

to technology-transfer restrictions. But hardest of all was "to sell Russia as an opportunity within the company," Kravchenko says. Partly to that end, he spent seven of his 13 years with Boeing in Seattle, then headquarters, and makes sure senior managers like Yermonsky still camp there three months a year. (Tom Cogan, by contrast, was last in Russia three years ago, and remembers learning "When your toes *stop* hurting, that's frostbite.")

Kravchenko seems an odd apostle of international brotherhood. A distracted mad scientist type, he pecks moodily at e-mails while hurling staccato answers in his overstuffed cubby of an office. Asked why he got the nod to start the Boeing organization, he replies: "I was the youngest member of the Russian Engineering Academy. I have two Ph.D.'s, one of them close to aerospace." End of story.

Yet Kravchenko has learned to think

THE BOEING COMPANY/12-2005

corporate along the way, speaking of "briefings from my direct reports" and "grooming our future leaders"—and seems to have his complex operation humming. Fourteen years after the crackup of Communism, design bureaus begun by Tupolev, Ilyushin, Sukhoi, and Antonov—the giants of Soviet aerospace—are nearing extinction. They have plenty of intellectual resources available too, but they lack the culture to mobilize them profitably.

Down the road, Kravchenko is looking to expand Boeing Russia beyond metal bending to the full spectrum of advanced technology. Boeing already outsources software design and troubleshooting to Moscow-based IBS, Russia's top systems integrator. Kravchenko has said he would like "Boeing to do for Russia what GE did for India," recalling the key contribution that orders from General Electric played in launching the Bangalore tech hub. But he may have competition. In February, Airbus announced it was in talks with the Russian government to invest $25 billion in the country by 2030, giving Russian enterprises a major role in whatever Airbus builds to counter the 787.

CRAIG MELLOW

# High Flier

ERIC LONG

**Will Lee is part of a team of craftsmen working at the Garber facility to prepare a Northrop P-61C Black Widow for display at the Steven F. Udvar-Hazy Center.**

Dressed in layers to protect himself against frigid air, test pilot Donovan Heinle took off from California's Moffett Field in an unusual-looking twin-boom aircraft painted black. Headed south toward Edwards Air Force Base in the Mojave Desert, he took the unpressurized airplane, a Northrop P-61 Black Widow, to an altitude of 41,000 feet. As Heinle brought the P-61 over a bombing range, he released a swept-wing test body mounted underneath; while it fell, reaching low supersonic speeds, onboard instruments recorded flight data before air brakes and a parachute broke its landing.

From 1951 to 1954, Heinle and other pilots flew the P-61 as a mothership on some 50 flights, dropping recoverable bodies as part of a National Advisory Committee for Aeronautics program to research swept-wing aerodynamics. When the NACA Black Widow, a C model, came off Northrop's production line in the summer of 1945, it had a powerful nose-mounted radar and was armed with four 20-mm cannon and four .50-caliber machine guns. P-61 A and B models had moved unseen through night skies to shoot down enemy aircraft in the European and Pacific theaters of World War II, but with combat winding down, C models seemed destined to become museum pieces.

In October 1950, the U.S. Air Force donated a P-61C, serial number 43-8330, to the Smithsonian Institution's National Air Museum (it became the National Air and Space Museum in 1966), and the aircraft moved temporarily to the Museum's storage facility at Chicago's O'Hare International Airport. Before the Museum could make arrangements to ferry the Black Widow to Washington, D.C., however, the NACA asked to borrow it. In a letter addressed to Museum curator Paul E. Garber on

ARTIFACTS

## Going Mobile

Concerned that astronauts returning from the moon might harbor extraterrestrial microorganisms, Apollo program directors at NASA quarantined the space travelers in Airstream trailers outfitted with living and sleeping quarters, plus a kitchen and a latrine. NASA built four Mobile Quarantine Facilities, one of which is now on display at the National Air and Space Museum's Steven F. Udvar-Hazy Center at Washington-Dulles International Airport in northern Virginia. The Museum's Airstream was occupied by the crew of Apollo 11—Neil Armstrong, Buzz Aldrin, and Michael Collins—for 65 hours after their capsule splashed down in the Pacific. With the men inside, the Airstream was transported aboard the USS *Hornet* aircraft carrier, eventually arriving at the Lunar Receiving Laboratory at the Johnson Space Center in Houston, Texas. The quarantine ended after NASA scientists determined that the astronauts were free of moon germs.

DANE PENLAND

**Living in a trailer was all part of being an astronaut.**

November 30, the NACA's assistant director for research, I.H. Abbott, spoke of his agency's "urgent" need to obtain a P-61 to use as a high-altitude research craft. Garber agreed to an indefinite loan, which lasted until June 1954, when the NACA concluded its use of Black Widows to drop test bodies. NACA pilot Heinle made his last flight in the P-61 when he ferried it from Moffett Field to Andrews Air Force Base in Maryland, arriving on August 10. The Black Widow was stored there, alongside such other Museum artifacts as the Boeing B-29 *Enola Gay* and the Douglas XB-43, for seven years before being moved to the Museum's Garber storage and restoration facility in Suitland, Maryland.

In January, the Black Widow was moved into Building 10 so Garber's 19 restoration specialists, three conservationists, and three shop volunteers could focus solely on refurbishing the airplane for its unveiling at the Steven F. Udvar-Hazy Center on June 8; that day, a panel of former Black Widow air crew, including former Northrop test pilot John Myers, will speak about their experiences flying the aircraft.

Observing the restoration one day last April felt like walking through a crime scene, with dozens of dismembered parts—a wing here, an engine cowling there—strewn around various work stations in Building 10. ("If it's black, it's the P-61," says project manager Karl Heinzel.) The fuselage—minus engines, twin booms, and wings—is enormous (a fully loaded P-61C weighed 35,855 pounds). With a double-canopy in front for the pilot and gunner and a double-canopy in the rear for the radar observer/gunner, it's difficult to distinguish nose from tail on the brutish aircraft. "The P-61 was not a thing of beauty from the aesthetic viewpoint; but it was a beautiful ship to fly," wrote former Northrop test pilot Moye Stephens in a letter to the Museum. "It didn't have a wicked bone in its body, and would tolerate mishandling that would have proved fatal in other twins."

Years of sitting outside had taken its toll on the Museum's P-61, which had patches of corrosion; animals had also left nests and droppings ("Everything that lives outside gets inside," says Heinzel). Besides cleaning up the aircraft and arresting corrosion, the Garber team replaced the tattered fabric covering the control surfaces, restored the broken and incomplete instrument panel, and found a contractor to make replacement canopies because the plexiglass of the originals had yellowed and cracked.

During the P-61's tenure as a research vehicle (it also flew for the Flight Test Division at Wright-Patterson Air Force Base in Ohio), its armament and dorsal turret were removed to reduce weight, but the Garber team has no plans to return the aircraft to a wartime configuration. Heinzel defends the decision, proudly pointing out that the Museum's Black Widow made a "very early contribution to swept-wing supersonic research." So what if the Museum's P-61 never saw combat—it didn't need to.

DIANE TEDESCHI


NASM (SI NEG. #SI72-7873)

**Northrop built 13 YP-61s, which were used for flight testing. This YP-61's dorsal turret sported two guns, whereas later designs had four; counting the belly-mounted cannon, the P-61 was the most heavily armed fighter of the war.**

## VISITOR INFORMATION

**June 13** Lecture: Exploring Weather and Climate—A History of "Cutting Edges" and "Killer Apps." Free tickets can be obtained online through *www.nasm.si.edu*; for more information, call (202) 633-2398. Lockheed Martin IMAX Theater, Museum on the Mall, 8 p.m.

**June 17 & July 22** Saturday Star Party. Observe celestial objects in dark skies unpolluted by city lights. Sky Meadows State Park, Virginia, 8:30 p.m. to 11 p.m. Parking fee: $4 per car; park phone number: (540) 592-3556.

**Curator's Choice**

Occasionally a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest at either the National Air and Space Museum on the Mall or the Steven F. Udvar-Hazy Center in northern Virginia. In the Museum on the Mall, meet at noon at the gold seal near the Information Desk; in the Udvar-Hazy Center, at the nose of the SR-71 Blackbird aircraft at 12:30 p.m.

Museum on the Mall: June 7, V-2 mobile launch operations; June 14, Robert McCall's space art.

Udvar-Hazy Center: June 1, Apollo 12 camera; June 15, Bell XV-15 Tilt Rotor.

**Boeing Donates $15 Million**

The National Air and Space Museum has received a $15 million donation from the Boeing Company; it is the largest single corporate gift ever presented to the Smithsonian Institution. The gift will help fund Museum programming, the care of artifacts, and the remaining construction at the Steven F. Udvar-Hazy Center. In recognition of the donation, the central structure at the Udvar-Hazy Center will be known as the Boeing Aviation Hangar. "Boeing has stepped forward with a timely, magnanimous gift," said Lawrence M. Small, Secretary of the Smithsonian. "We are very grateful for this vital support from a true friend of the Smithsonian."

# Operation Hot Wheels

In the spring of 2003, I watched in delight as 10 midget racecars—one shaped like an airplane, some rolling on gigantic wheels, all handmade of used hardware and scrap wood—barreled along a makeshift half-mile course carved in the desert. A crowd lined the route, braving hundred-degree heat to watch this unique soapbox derby in the midst of a war, on an air base far from home.

We had arrived at the small aerodrome, tucked away in a remote location in the Middle East, on a blazing hot morning in March. The cargo door of our KC-135 Stratotanker opened with a hum, and we braced ourselves against the inrush of scorching heat and sun. We scrambled down the crew ladder to the concrete ramp and breathed the desert air. Nine other airplanes would touch down around us, unloading another 100 maintenance troops to join our initial contingent of 20. We were all Air Force reservists, activated and immediately shipped overseas to support combat operations during the first months of Operation Iraqi Freedom. Many of us barely had time to say goodbye to family, friends, and employers; none of us knew how long we'd be gone.

The air campaign for Operation Iraqi Freedom kicked off within two weeks of our arrival, and our squadron worked 12-hour shifts, day and night, to keep our Boeing KC-135 tankers flying. Airplanes were launching and landing within minutes of one another. We repaired the broken ones as fast as we could, towing them in careful zigzags around our tiny piece of the ramp. We installed new brakes, filled fuel tanks, swapped out malfunctioning equipment, and signed off each job by rubbing the airplane's belly for good luck.

But after the mid-April fall of Baghdad, our workload slowed considerably. Soon we found ourselves with too much time on our hands and not enough to keep us occupied during off-duty hours. The base had a well-stocked recreation center, but the troops could take only so many movies, pool tournaments, and video games. People were getting restless.

As squadron commander, it was my job to gauge the morale of the troops. We weren't going home anytime soon.

**FLYING OVER THE ASPHALT AND OCCASIONAL SPEED BUMP, A FEW DRIVERS WATCHED HELPLESSLY AS ACCESSORIES FLEW OFF AND WHEELS DISINTEGRATED BENEATH THEM. A HASTY YANK ON THE HAND BRAKE COULD CAUSE A MINOR TRAFFIC PILEUP.**

We were thousands of miles from our families, with a mission that was slowing by the day. Our aircraft maintenance personnel were good with their hands. Many of them loved to build things. I racked my brain for a project that would engage everyone.

I was terrible at driving manual-transmission vehicles, so of course I had been issued a pickup truck with a stick shift. One night, prompted by my lurching around the base, grinding the gears and praying I wouldn't stall out, the proverbial light bulb went on.

I talked to my squadron, and with their enthusiasm ringing in my ears, I drove up the road to pitch the idea to my boss. The worst he could do was to laugh me out of his office.

"You want to do what?" he said.

"A soapbox derby race," I said. "Like we did when we were kids."

He adjusted the glasses perched on his nose and thought for a minute. "What would the cars be made out of? There's no hardware store around here, you know."

"Scrap materials around the base," I replied. "Old soda cans, pieces of plywood, sheet metal, string, whatever we can find."

He nodded. "Tell me more."

"We'll form teams of four people each, and do it as a relay race around

NEAL FREEMAN

the camp," I went on. "One person will push the car, and another will sit in it and steer. At each checkpoint they'll switch out so the other team members have a turn in the driver's seat."

"It's nuts," he chuckled. "Go for it."

One of my fellow officers, Chuck, volunteered to help. He penned rules for the race, tacked up sign-up sheets at the recreation center, and challenged everyone to draft blueprints for cars. People laughed at the idea, but its very oddness proved appealing. A list of names grew on the sheet.

By the registration deadline, 10 teams had submitted construction plans. Our civil engineers supplied tools and basic construction materials. For the next month, the chatter and whine of power tools, hammers, and handsaws echoed throughout the camp. Overnight, airmen became craftsmen, turning out car parts one by one: wooden wheels carved by hand, frames fashioned from castoff plywood, steering mechanisms strung with knotted bungee cord. It was off-the-cuff engineering at its finest.

On race day, we unveiled the soapbox racers to the base. Some cars had headlights, license plates, and simulated dashboard gauges. The silver grille of Number 31 sported a faux Mercedes emblem. The nose of another car bore bloodshot eyes and sharp teeth. Two teams had crafted sleek vehicles resembling Formula 1 racers. The largest vehicle, fittingly numbered 01, resembled a monster truck. Slathered with bright orange paint, it featured exhaust pipes, a jumbo steering wheel, an air intake on the hood, and a rear-mounted rack for all four team members' safety helmets. A team of aircraft mechanics designed its entry to resemble a C-130 cargo hauler, complete with green paint, tiny wings, and a pilot's control wheel. Two little propellers jutted from each wing. Stenciled on the side was U.S. AIR FORCE.

Parked near the mini-C-130 was the most melancholy-looking racer of the bunch, the Flintstone-mobile, its chassis covered with leopard-print fabric. Taped to the seat was a piece of paper that read "Racers needed for this car! Team members are being forward deployed," a sobering reminder that a war still raged around us. At the last minute an ad-hoc group adopted the Flintstone car to drive in the race.

We hosted a short opening ceremony, played the national anthem, and a volunteer emcee fired the starter pistol. Jockeying for position, roaring ahead at the breakneck speed of 12 mph, the competitors dashed around the camp. The C-130 car was a green blur, its driver anxiously gritting his teeth as he steered the vehicle. At each quarter-mile, the driver and pusher jumped away from the car to be replaced by other team members. During one switch, a car careened sideways, requiring the replacement driver to chase it down the street until he was able to grab the steering wheel and maneuver back on course.

Flying over the occasional speed bump, a few drivers watched helplessly as accessories flew off and wheels disintegrated beneath them. A hasty yank on the hand brake could cause a minor traffic pileup. Over the next two hours, the better-designed racers rose to the top as the less fortunate were rolled to the side. The C-130 zoomed through heat after heat, its cardboard propellers spinning enthusiastically in the wind. The Flintstone car, wheels askew and leopard skin in shreds, begged to be put out of its misery. As it crossed the finish line, its left rear wheel popped off and the vehicle skidded to a halt. Unfazed, the driver thrust his arms in the air and cheered in mock victory. In the final heat, a soapbox racer sculpted like a bullet broke the tape at the finish line. We applauded the winning team, but more importantly, there were a lot of happy faces that afternoon. Later, the derby racers found new drivers: the children in the local village.

ALLAN T. DUFFIN

# The King Crab Caper


DAVID CLARK

Mike and Bill Wright used to fly an old forest-green Lockheed Lodestar, with aluminum foil covering the inside of the windows on the left side, from Chino Airport in California to somewhere in Washington State to pick up Alaskan King crabs at the dock and bring them back to restaurants in Los Angeles. The brothers always smelled of fish, and they had to park the Lodestar at the most remote spot at the airport.

One day in 1976, Bill was ill, and Mike needed a copilot. I jumped at the chance. I had just received my pilot's license, and I was hanging around Chino, hoping I would get to fly some of the old airplanes that lived there.

Once our heading and altitude were established, Mike turned the flying over to me. Wide-eyed and white-knuckled, I negotiated airways up California's Central Valley and on toward Oregon.

After we landed at Portland, Mike ordered gas and we retreated to a worn-out waiting area, where I spied a candy machine. Inserting a quarter, I pulled the handle under the Oh Henry bars. Two tumbled out, then the handle jammed. I jiggled and yanked it and more fell out. Soon all the Oh Henrys the machine had held were stuffed in our pockets.

Mike taxied to the end of the runway. "You take it," he said. Nervously I advanced the throttles while I kept an eye on the manifold pressure gauges. I was pushed back in my seat as the empty airplane accelerated. I had plenty of runway left, and since speed equals safety, I held it down until I had excess speed, then eased it off, having used more than three-quarters of the runway. An observer would have thought this Lodestar with the covered windows must be laden with cargo. As we later learned, there was an observer who thought so. He dashed for a Cessna Skymaster and followed us out of Portland.

We reached Bowerman Airport, outside Hoquiam, Washington, at sunset. Mike set up the approach and let me bring it in. I landed with a bounce, taxied to the office, and swung the tail around jauntily as the radial engines ticked to a stop. Mike trundled off toward the office and I opened a hatch and pulled out chocks.

"Freeze!" The voice was shrill, urgent, and adolescent. I looked over my shoulder into the barrel of an enormous pistol. Behind the pistol was a kid who looked no older than me. Mike turned around and the kid swung toward him. "Get down!" he squeaked, shifting the gun back and forth between us.

"What's going on here?" Mike yelled. "We don't have anything!" But he knelt and I followed suit. The kid handcuffed us and held us at gunpoint as a sheriff's car screeched to a stop, doors flying open. A second car swerved around the office, and soon we were surrounded by uniformed officers, guns drawn. It finally dawned on me that we were not being robbed, but arrested. For what, I had no idea. Then I remembered the Oh Henrys. I wanted to give up the take but couldn't because of the handcuffs.

A few minutes later a Skymaster taxied up and disgorged more gun-wielding agents. As we sat back to back under the airplane, one of the team opened the door and flinched from the smell. Mike tried to explain that we were crab haulers, not drug runners. Someone found a cardboard box in the cargo hold, but hopes were dashed when all that was found was a spare cylinder for the engine. Other officers removed floorboards, finding only control cables and brackish residue.

The officers finally realized their big drug bust was just a couple of guys hauling seafood. Then the truck we were waiting for pulled up. Guns were brandished and the driver was dumped onto the ramp and cuffed. Someone swung the truck's doors open to find empty trash cans and the same odor as our cargo hold had.

Finally, they let us go. We put our airplane back together. I had an Oh Henry. We loaded crabs into trash cans, then stuffed them aboard. It was well after midnight when we took off.

Mike got us to altitude, gave me the airplane, and went to sleep. The sun broke the horizon, filling the cabin with a warm glow. I realized why the left windows were covered. The crabs needed to be kept cool for the restaurateurs planning their menus.

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# Cessna's Golden Oldie

## 35,000 SKYHAWKS SOLD

BY ROGER A. MOLA

THERE'S HARDLY A PILOT flying today who hasn't logged at least a few hours in a Cessna 172 Skyhawk. It's the world's best-selling single-engine airplane, with more than 35,000 built since it began rolling off the Wichita, Kansas production line 50 years ago.

Basically a Cessna 170 (the company's original four-seat aircraft) with Land-O-Matic tricycle gear replacing the conventional tailwheel arrangement, the Skyhawk has changed little from its original simple, rugged, and reliable design. The 172 uses large Para-Lift flaps for better control at low speeds. The Skyhawk shifted to a swept-back vertical tail in 1960 and replaced the "fastback" fuselage with a rear window in 1962. Cessna also built 172s in France when it acquired an interest in Reims Aviation in 1960, stopped production entirely in 1986 due to the high cost of liability, and resumed production in Independence, Kansas, 10 years later, after the General Aviation Revitalization Act became law.

SVEN DE BEVERE

The last week of July, Joe Nelsen will fly his C-172, the first production model Skyhawk, to the Experimental Aircraft Association AirVenture in Wisconsin, where Cessna Aircraft, the Cessna Pilots Association, and thousands of airplane enthusiasts will make the annual pilgrimage to Oshkosh to celebrate 50 years of Skyhawks.

### 1956 Cessna Skyhawk Model 172

**Length:** 26 ft. 6 in.
**Wingspan:** 36 ft.
**Height:** 8 ft. 11 in.
**Powerplant:** Continental O-300A
**Horsepower at 2,400 rpm:** 145
**Propeller:** Two-blade fixed pitch
**Basic empty weight:** 1,376 lbs.
**Total usable fuel:** 42 gal.
**Rate of climb:** 660 ft. per min.
**Service ceiling:** 15,500 ft.
**Base price:** $8,700

### 2006 Cessna Skyhawk Model 172R

**Length:** 27 ft. 2 in.
**Wingspan:** 36 ft. 1 in.
**Height:** 8 ft. 11 in.
**Powerplant:** Textron Lycoming IO-360-L2A
**Horsepower at 2,400 rpm:** 160
**Propeller:** Two-blade fixed pitch
**Basic empty weight:** 1,639 lbs.
**Maximum speed** (at sea level): 142 mph
**Service ceiling:** 13,500 ft.
**Rate of climb:** 720 ft./min.
**Total usable fuel:** 53 gal.
**Base price** with standard avionics and the front-seat inflatable restraint system: $172,500
**Options** include air conditioning ($21,950), special finishes, and upgrades, such as a flat-panel-display cockpit.

JAY ROYSTON

## Pick a Peck of Skyhawks

In the Third February 2006 issue of *Trade-A-Plane*, classified ads listing C-172s for sale number 220.

DAN STROEING

ANDY BARRON

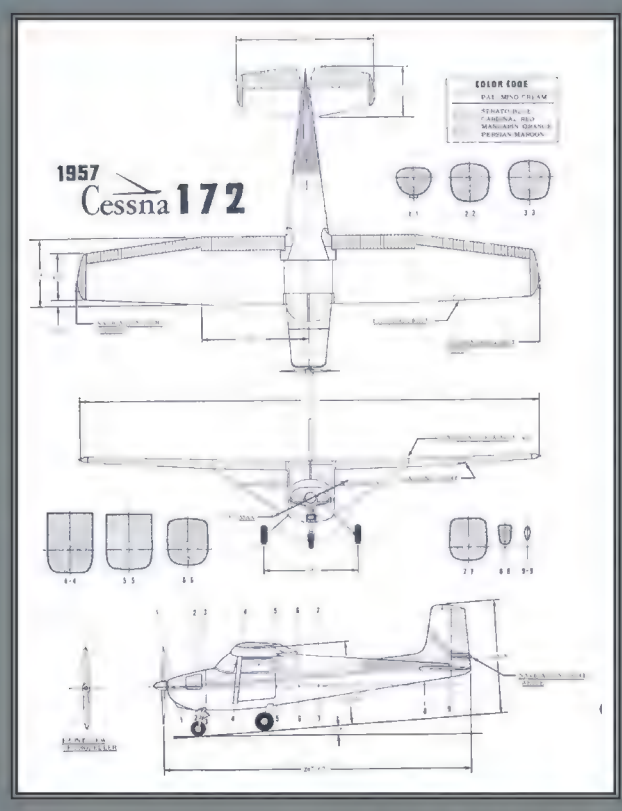
## The Skyhawk Joins the Air Force

USAF

The U.S. Air Force began using an off-the-shelf Skyhawk in 1964, designating it the T-41 Mescalero and eventually ordering 855 of the aircraft in ever more powerful versions from models A through D, the latter with a 210-horsepower engine and a variable-pitch propeller. The Air Force and Naval academies used the T-41 to train cadets, while the U.S. Army used it for reconnaissance. Beginning in 1993 the U.S. military phased out the Mescalero in favor of more aerobatic aircraft, but the T-41 still flies with the military of 24 nations, from Angola to Turkey.

## Staying Power

On December 4, 1958, Bob Timm and John Cook set out from Las Vegas' McCarran Field in a Skyhawk painted in the neon logo of the Hacienda Hotel to raise money for cancer research. The pair set an endurance record that still stands, staying aloft for 64 days, 22 hours, 19 minutes, and five seconds. The pilots flew in four-hour shifts and once a day descended to 20 feet above the desert highway to receive 95 gallons of fuel from a tanker or, occasionally, a classic Thunderbird. In 1959, the Hacienda Skyhawk landed in the *Guinness Book of World Records*, and now hangs above the baggage claim at what is now McCarran Airport.

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# SUPER DU

## WHAT'S TO KEEP US FROM FLYING 1,500 PASSENGERS? (NOT PHYSICS.)

# PERJUMBO

HOW BIG CAN an airplane get?

Airbus Industrie's A380, undergoing certification tests now, has racked up some impressive statistics: a length of 239 feet, a tail as high as an eight-story building, and a 262-foot wingspan. It can carry 853 passengers on two levels, if you cram them all into economy seats. It has 17 restrooms, is heavier than 16 semi trucks (1.23 million pounds fully loaded), and can accommodate 81,893 gallons of fuel and 6,492 mini-bottles—or thereabouts.

**Towed by a truck specially designed to tug it, the A380 debuted in Toulouse, France, in April 2005. Below: Future airliners could be twice as big as today's.**

**BY MICHAEL MILSTEIN**

But the A380 is not as big as an airplane can get.

An airplane can be as big as you want, say researchers who have tested the question against the laws of aerodynamics. The Russian Antonov An-225, a six-engine jet produced in 1988 to carry the Russian space shuttle, is bigger than the A380, with a span of 290 feet and a takeoff weight of 1.32 million pounds. Howard Hughes' *Spruce Goose* is even bigger. And Airbus is already hinting at a stretch A380. When it comes to hauling people through the air, size is an advantage. But at some point, does size become a handicap?

At about the time Airbus committed to the A380, Ilan Kroo, a Stanford University professor of aeronautics and astronautics and a leading aircraft designer, tried to answer that question.

Kroo worked with several other aerodynamicists on a NASA-sponsored study to evaluate the effects of size on aircraft performance and cost. He and his colleagues first believed that the growth of an aircraft would bump up against the square-cube law, a principle first outlined by Galileo that suggests that everything has a maximum size. In mathematical terms, the law states that when an object increases in size, its weight multiplies faster than the strength of the structure that supports it. In the case of an airplane, the engineers feared that the weight of a hypothetical craft would grow faster than the lifting ability of its wings until at some point you couldn't build wings long enough and sturdy enough to get the whole thing into the air.

But the square-cube law turned out not to limit the size of airplanes until the craft grow much bigger than the A380. "The basic physics that makes flying insects

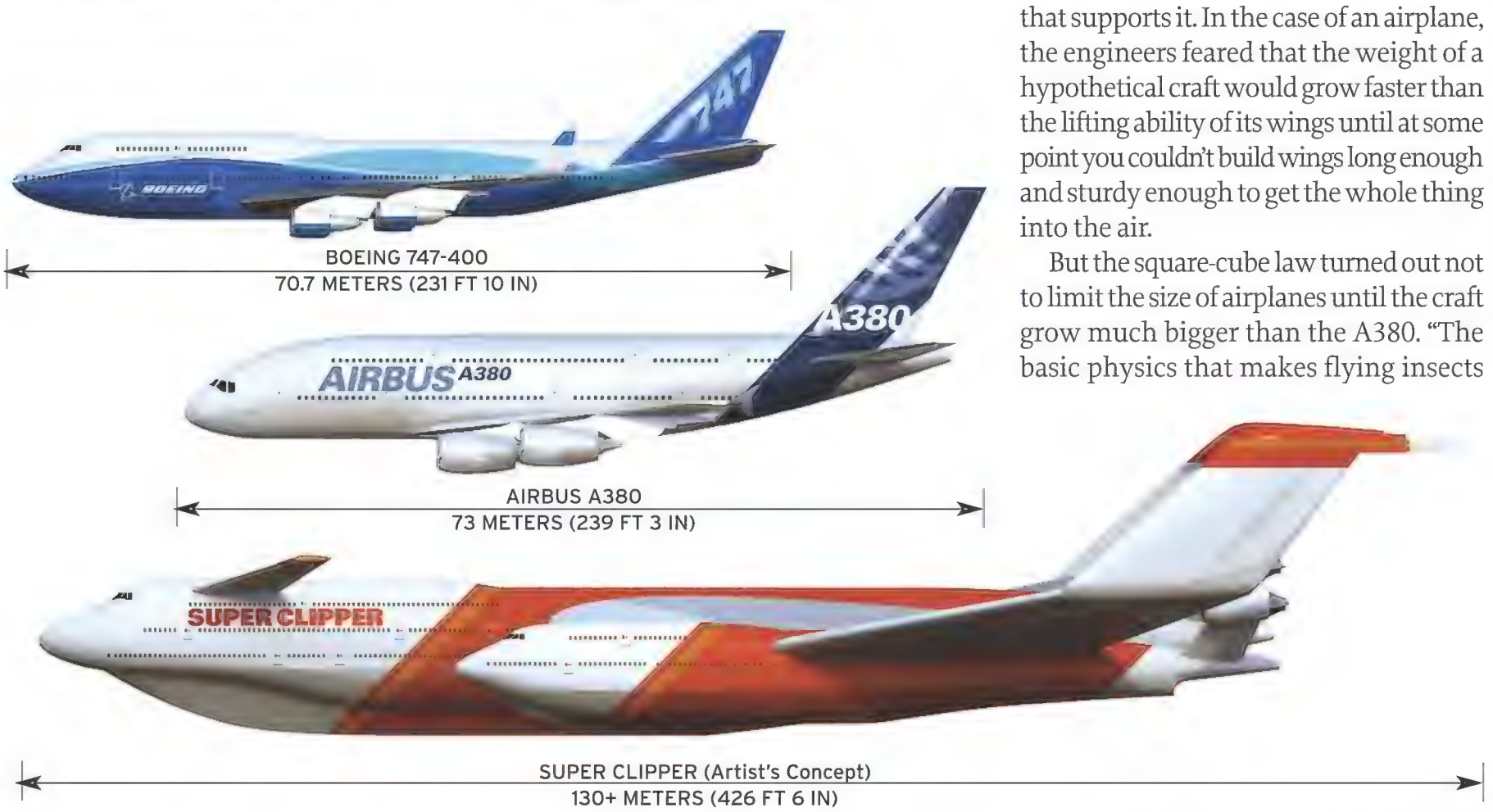



ILLUSTRATION: JOHN MACNEILL; OPPOSITE: MARK WAGNER/AVIATION-IMAGES.COM


AIRBUS

**Upper-deck passengers have their own exit and jetway to expedite boarding at A380 gates. Below: At Changi Airport in Singapore, planned departure site for the A380's first passenger flight, an existing bridge was strong enough for the giant.**

common and flying elephants impossible is not the main factor limiting the size of future aircraft," Kroo says. He measured the lift-to-drag ratio—the aerodynamic efficiency—for aircraft ranging in size from a 92,000-pound weakling with a span of 75 feet to a whopper that would weigh about 2.5 million pounds on takeoff, about twice as much as the A380. Its wings would stretch 392 feet, half again as long as the Airbus' and almost twice those of a 747. You'd need a roadmap to find your seat. It had a better lift-to-drag ratio than the smaller designs.

That a larger wing is more efficient may seem counterintuitive, since a longer wing on a heavier aircraft will need added structure to handle the increased loads from lifting that weighty fuselage. But Kroo found that the weight added to strengthen the wing was only a modest fraction of the airplane's overall weight—modest enough not to impose a significant penalty. Given a fixed span, in this case a very long one, the aerodynamicist would strengthen the wing by lengthening its chord (the distance from its leading to its trailing edge) and making it thicker—creating a deeper, structural box. Increasing size also confers some advantage in Reynolds number, a parameter that reflects how the size and speed of an object affect the resistance it meets from the fluid (in this case, air) it moves through. The airplane's larger wings experience less drag per square foot of area.

"It's hard to beat a bigger wingspan," says William Mason, an aerodynamics professor at Virginia Polytechnic Institute and State University. "If you wanted to make your design more efficient, that's probably the first thing you would do."

Airbus didn't have that luxury, and one number came to dominate the airplane's design—and perhaps its future: 80 meters, or 262.5 feet, the limit placed on its wingspan by airport authorities. In 1999, when Airbus and, at the time, Boeing, were contemplating superjumbo airliners, the International Civil Aviation Organization worked with manufacturers, airports, and its member agencies—including the U.S. Federal Aviation Administration—to establish standards for aircraft with wingspans greater than 65 meters, the limit established when the 747 was introduced. The participants determined the dimensions of arrival and departure gates, widths of runways and taxiways, spacing between parallel runways, and strength of bridges that the larger airplanes would need to traverse. One result of their work is the "80-meter box" at terminal gates. It's spacious for most airplanes, but for the A380 it's a struggle. Smaller Airbus airliners, scaled up to the size of the A380, would have quickly punctured the sides of the 80-meter box. The big brother, therefore, ended up with stubbier wings than its siblings. The A380's wingspan, 79.75 meters, squeaks about as close to the boundary as Airbus could get. It leaves less than six inches on either side. Pulling into a gate will be like squeezing into a garage with an eighth of an inch on either side of your car.

Charles Champion, the number-two officer at Airbus and head of the A380 program, acknowledges the company paid an aerodynamic penalty for the 80-meter box. The A380, he says, is a giant flying compromise between the aerodynamic and financial forces that say that say bigger is better and the practical realities of assembling the behemoth and bringing it back down to earth.

With the A380 limited in wingspan, its designers looked to power: They'd need

four engines blasting a total of 280,000 pounds of thrust—more power than any other commercial airliner—to lift it into the air. The Engine Alliance, a joint venture of General Electric and Pratt & Whitney, makes one of the two engines available for the A380. (Rolls-Royce makes the other.) Engines that power modern airliners use large fans at the front to suck in huge amounts of air. The bigger the fan, the greater the volume of air forced rearward and therefore the more thrust an engine can produce. The Engine Alliance fan has a diameter of 9.7 feet and is rated at 76,500 pounds of thrust (and produced 94,000 pounds during testing). That's big, but it's not the biggest jet engine. That title goes to the one on the twin-engine Boeing 777, with a fan measuring 10.7 feet and blasting up to a record 122,965 pounds of thrust.

If Kroo's superduperjumbo had to take off on today's international airport runways, it would need somewhere between 500,000 and 750,000 pounds of thrust to get off the ground in the runway length allotted. With a reasonably efficient wing, an aircraft needs thrust equal to between 20 and 30 percent of its takeoff weight to lift off from a runway of about 10,000 feet, the typical length of runways at today's international airports. (If the engines could provide thrust equal to 100 percent of the takeoff weight, says Kroo, "you could go straight up.") To provide enought thrust to the superduperjumbo—more than 500,000 pounds—you'd have to equip it with eight of the massive engines that power the A380—compared to the four on the Airbus. (Hanging eight engines has been done before—on Boeing's B-52, for example.)


AIRBUS


ANDREW HUNT/AIRTEAMIMAGES.COM

**Wheeee! Exit slides from the upper deck of the new Airbus are almost 30 feet long but designed to appear less steep to the passenger about to descend. In a test last March, 873 people exited the airplane within 78 seconds.**

The cost of a bigger engine is more weight, requiring the airplane to carry more fuel to fly with the extra weight, and still more fuel to carry the weight of the extra fuel, says Bruce Hughes, Engine Alliance president. To compensate, designers scoured the A380 engine for ways to shed weight—thinning its walls, shaving its airfoils, and using hollow titanium blades sculpted like sinuous modern art. After dozens of trade-offs, engine and airframe designers came up with the power-to-weight ratio needed.

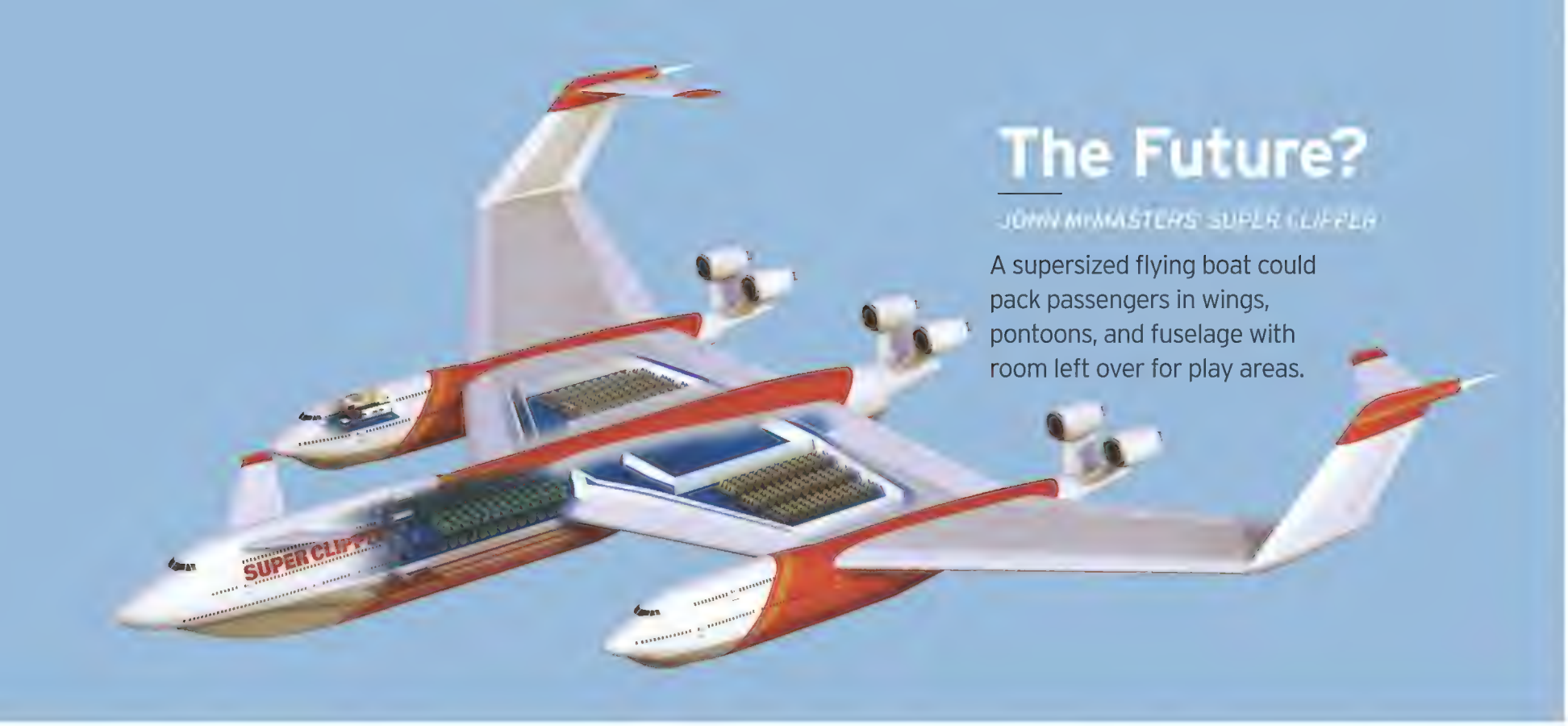
"There's no reason you couldn't just keep building bigger and bigger planes," says Dennis Bushnell, chief scientist at NASA's Langley Research Center in Virginia, who has studied designs for very large passenger aircraft. "The problem you run into is whether the airport infrastructure can handle them, and whether you have the margin of safety that you need to have."

John McMasters, an aerodynamicist at Boeing who worked with Kroo on his 1996 analysis of large aircraft, contemplated the problems of fitting the beasts into existing airport infrastructure and found a way out: He designed a seaplane. That way, he reasoned, he wouldn't have to worry about finding a runway big enough to land on. He calls his concept the Super Clipper, a modern successor to the luxurious flying boats that Pan Am designed in the years before World War II, when runways were scarce. The vast, 239-foot wings of his design would be supported with floats made from the fuselages of 747s, which would themselves carry some of the Super Clipper's 1,200 passengers. Though it might fly slower than today's aircraft, it would make up for its leisurely speed by offering its passengers enough room for jogging tracks, ballrooms, and wine bars—featuring Las Vegas-style lounge acts on selected routes.

"If you're going to do a big plane, why don't you do something grand?" McMasters says. "The airlines like big planes because they move lots of people. Why not build something people will like too?"

McMasters' seagoing Super Clipper is a fanciful extrapolation from his study of large aircraft configurations. He has also studied the prospect of a giant flying wing, a design that NASA has continued to study. At this point, Boeing's interest is purely in military applications, and the company will fly a scale model of the Blended Wing Body aircraft at NASA's Dryden Flight Research Center in California this fall. If a full-scale commercial version were to be developed, it would face the same problem the A-380 faces: airports.

London's Heathrow is the third busiest in the world (after Atlanta and Chicago) and, as the airport handling more international travelers than any other, probably the most cramped for space. When Airbus designers approached airports around the world starting in 1996, Heathrow was enthusiastic because the A380's capacity could squeeze more people into each of its coveted landing slots.




## The Future?

JOHN McMASTERS' SUPER CLIPPER

A supersized flying boat could pack passengers in wings, pontoons, and fuselage with room left over for play areas.

ILLUSTRATION: JOHN MACNEILL

The airport now expects 65 superjumbo flights a day by 2015.

But big airplanes create big demands on the ground: Heathrow is spending about $800 million to rebuild itself, widening runways, adding taxiways, lengthening baggage conveyors, and renovating a terminal to create four superjumbo-size gates almost as wide as Big Ben is tall. The airport is also building a new terminal, to be completed by 2011, that will include 14 gates that can accommodate the A380; two of the 14 opened this year.

In Singapore, where Singapore Airlines has ordered 10 A380s, with options for 15 more, costing a total of $8.6 billion, and where the first commercial A380 flight will likely take off early next year, Changi Airport is expanding 19 gates with extra seating, restrooms, and three jetways to handle A380s. Crews at Changi, which promises to be a hub for the megaliners on crowded Asian routes, have widened runways, expanded runway-taxiway intersections, and added shields to block the intense blast from the A380's engines.

Airbus designed the A380 so airports wouldn't have to strengthen existing runways. Though it weighs far more than a 747, its tires put no more pressure on runways because its weight is spread out over more wheels: 22. The immense weight of the new airliners does require some airports to reinforce bridges they will use. Its span and engine placement require them to widen runways from 150 feet, the standard for a 747, to 200 feet. Some airports, such San Francisco International, will work around that requirement by closing adjoining taxiways when an A380 arrives.

Airbus has strained to coax every bit of per-passenger performance possible from its superjumbo, and that's the reason the airplane has two decks. Airplanes that pack people onto two levels—like the A380—or even three levels—like Kroo's superduperjumbo—make more efficient use of their space. Kroo figured that by stacking 1,500 passengers in an airliner's triple-deck fuselage, for example, he would reduce the ratio of nonlifting fuselage area to lifting wing area, which would reduce the power needed to carry each person. (Pity the poor pilot who'd have to stand there and say goodbye as all those people file off.)

But the payoff multiplies not only because per-person thrust is optimized but because the basic costs of flying any airliner—the salary of our friendly pilot, for instance—are spread across the ticket price of more passengers, so the cost of moving each person is smaller.

"You get some help from the aerodynamics [in a larger airplane], but you get even more help by putting another 50 to 80 people on it," says William Crossley, a professor at Purdue University's School of Aeronautics and Astronautics in Indiana. "That's why the airlines really like it. They're in the business of moving people, and the more people they can move, the better."

Moving more people through the air, however, sometimes seems easier than moving them on and off an airliner. The A380, says Airbus, is focused on efficient loading and unloading. The exits were located so that once the airplane pulls up to the terminal, passengers can gather their belongings and get off quickly, and

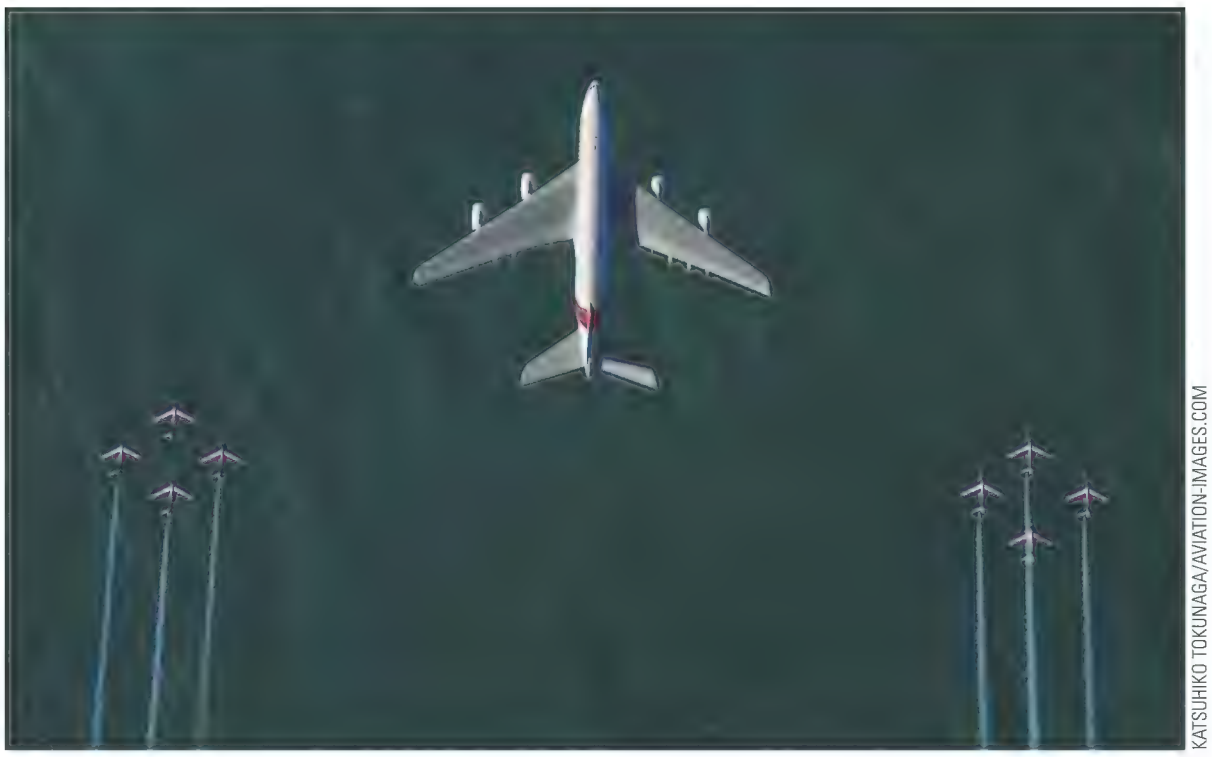

the next load can get on and fasten their seatbelts—all in 90 minutes, keeping time on the ground to a minimum.The ultimate test of exit efficiency, however, would come in an emergency, and the FAA and the European Aviation and Safety Agency required Airbus to load the A380 to maximum capacity and then get every last one of its 853 passengers off within 90 seconds. The test had to mimic real emergency conditions: At least 35 percent of the "passengers" were over 50 years old, at least 40 percent were women, carry-on baggage and pillows were strewn about the cabin, and only half the airplane's doors were workable. And the evacuation had to be performed in total darkness.

Last March in Hamburg, Germany, 853 volunteers and 20 crew members left an A380 in 78 seconds. One man broke his

leg and there were several other minor injuries, but the airplane passed the test.

Risk analysts wonder if a test can truly simulate all real world conditions. Emergency exit slides are rated to inflate within 10 seconds even in a 25-knot wind, but a critical question for the A380 is whether passengers will balk at sliding almost 30 feet from the uppermost deck. Passengers must leap onto the slide faster than one per second, so more than a blink of hesitation will clog the flow.

**Dwarfing French Alpha Jets in Dubai (right), or showing up its little brother at home (below), the A380 lives large, with Rolls-Royce Trent 900s (bottom.)**



KATSUHIKO TOKUNAGA/AVIATION-IMAGES.COM


AIRBUS

MARK WAGNER/AVIATION-IMAGES.COM

Exit slides, made by North Carolina-based Goodrich, are designed so the slope doesn't look as steep as it really is, Champion says. But exit slides were a problem for at least one passenger very familiar with airliners. Juan Trippe wanted the Boeing 747 to be a double decker for the economic advantage, but it ended up with only a partial upper level in its hump after Trippe was invited to try out an exit slide—and chose the stairs instead.

One of the more contentious issues in the A380's test program was the danger of the vortices the airliner will trail. Air swirling around the wings not only cuts into performance, it also trails the wings in the form of invisible whirlwinds. Every airplane creates them, but the heavier the airplane and the shorter its wingspan, the more powerful they can be.

To an airplane moseying behind, a vortex may seem like no more than a little speed bump, but the whorl could also act like an unseen hand, suddenly flipping an airplane upside down. Aviation authorities manage the problem by imposing buffer zones between aircraft, especially on takeoff and landing, when vortices are most dangerous. A light aircraft, like a Cessna 172, must stay at least six miles behind a 747.

Through wind tunnel tests and computer modeling, Airbus adjusted the A380's wing design to keep vortices in the same range as those of a 747, but the International Civil Aviation Organization said early simulations and preliminary flight test data found much more powerful vortices, and ordered aircraft to stay at least 10 miles behind the Airbus. Congested airports like Heathrow would have to space flights out so widely they'd lose the advantage of packing more people onto the bigger airplane. An anxious Airbus has now committed to measuring vortices as the A380 continues its early flights at various locations around the world. It's doubtful the 10-mile buffer will stick; a similar buffer imposed on the 747 when it first entered service turned out to be stricter than necessary.

Kroo's imaginary 1,500-seater would no doubt trail monster vortices. Long wings dampen the whirlwinds, but no little Cessna would want to get within many miles. Perhaps airports and regulating authorities would find a way to channel traffic to lessen the impact of a superduperjumbo.

Richard Marchi of Airports Council International says that airports are adjusting to airplanes with larger, more efficient wingspans. "If aerodynamics are going to drive you to a bigger wing, then the airports are going to accommodate it eventually," he says.

Boeing's humped 747 entered service in 1970 as the biggest airliner in history amid fears that it too would be more trouble than it was worth. But in an era of booming air travel, it proved so popular with airlines that it turned out to be one of the most successful airplanes in history—1,117 are still in service today.

No doubt there is some size at which an airplane would be too big to get off the ground, Ilan Kroo says. But he hasn't found it yet.

# We Haul

DIAL MI-26 HEAVY. ASK FOR TISHCHENKO'S BIG RIG.

# It All

OPPOSITE: IGNATIY SAVRANSKIY; LEFT: SCORPION INTERNATIONAL SERVICES

**The house-size Mil Mi-26 could sleep 100 comfortably. The heavy-lift helicopter is employed by the United Nations on humanitarian missions—here, in Belarus in May 2005. Scorpion International used one to haul out a picked-over Grumman Albatross in Greece last year (above).**

IN THE SPRING OF 2002, high in the mountains of eastern Afghanistan, Lieutenant Colonel Chuck Jarnot found himself in need of a really big lift.

Jarnot, at the time the senior U.S. Army aviation liaison officer between the Third Brigade, 101st Airborne Division and the 10th Mountain Division, was charged with tidying up after Operation Anaconda, an attempt in early March to drive al Qaeda and Taliban fighters out of the Shahi-Kot Valley and surrounding mountains. It ended three weeks later with eight U.S. and several hundred enemy soldiers killed, and two damaged Special Forces Boeing MH-47E Chinook helicopters stranded on the slopes above Sirkhankel at 8,500 and 10,300 feet.

**BY JOHN CROFT**

Given his background—a master's degree in aeronautical engineering from Embry-Riddle Aeronautical University in Florida—Jarnot was the go-to guy for figuring out how to get the Chinooks off the mountain. The obvious solution was to make the downed helicopters as light as possible and airlift them to Kabul, a 45-minute helicopter flight to the north. With fuel drained and rotor blades and all non-essentials removed, the Chinooks each weighed about 26,500 pounds.

Jarnot checked a *Jane's All the World Aircraft* reference book and tinkered with the numbers, adjusting the computed sea-level performance for the debilitating effects of altitude on helicopter performance. The largest lifters in the U.S. military's stable—the Chinook and the Sikorsky CH-53E Sea Stallion—could each lift about 20,000 pounds at 8,500 feet, less at the higher elevation.

Though the helicopter at 10,300 feet turned out to be too badly damaged to salvage, there was an option for saving the other: Find a Russian heavy lifter known as the Mi-26. Rarely seen

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**Mikhail Mil (left), a rotor man since his 20s, founded the eponymous helicopter design bureau in Moscow in 1947. His protégé, Marat Tishchenko, became plant manager after Mil died in 1970.**

in the West, the Mi-26, according to *Jane's*, is the "largest ever production helicopter." Jarnot took the idea to his commanding officer. "If you got the cash, we can get on the Internet and try to outsource the job," he told the commander, adding, "*Jane's* showed the Mi-26 had enough oomph to get it off the mountain."

Oomph is what the Mi-26 is all about. Since its introduction in 1980, it has been the undisputed rotary-wing heavy-lift world champion. With a cargo hold as capacious as that of a C-130 Hercules, the helicopter at sea level can lift as much as 20 tons in the cabin or on an external sling. That's more than four tons over what the U.S. military's largest lifter, the CH-53E, can haul, and more than seven tons over the capacity of the Boeing Vertol 234 civilian variant of the Chinook.

The Mi-26 is so large it wreaks havoc with one's sense of scale. Most striking is the helo's main rotor system, which spans 105 feet and stands nearly 27 feet tall. Each of the eight blades is more than 30 inches wide, and the tail rotor is about the size of the main rotor on a Robinson R22 trainer.

To see one up close, I went to Brussels to meet Thierry Lakhanisky, the young chairman and CEO of Skytech Heavy Lift Helicopter Services and one of the few operators of civilian Mi-26s in the world. A computer scientist by trade, Lakhanisky learned to fly helicopters in the United States, then started Skytech in Belgium at age 21. At one point in the 1990s, he had a few dozen helicopters, but now leases just seven heavy-lift Russian helicopters.

Skytech had two Mi-26s on the ramp at Charleroi Airport. They loomed over us as we walked toward them, and I began to sense how gigantic they are by how long it took to reach them. We pulled a cabin door down, and I felt as though we were stepping up into a building. Lakhanisky's wife, struggling for the right translation, had called the spartan interior "rude." Actually, the word was not far off, for the machine and its designers put the priority on hard, heavy work.

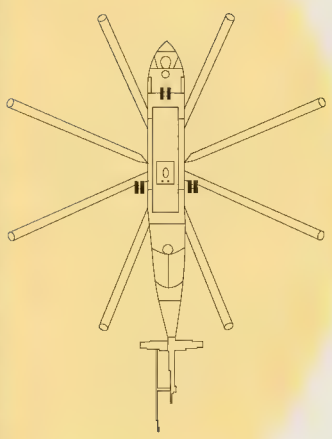
The leviathan was the product of nearly two decades of research and development at the Mil Design Bureau in Russia, one of several government facilities that, in the era when all military and civilian aviation industries were owned by the state, would design or modify an aircraft, create a prototype, then turn the production process over to industry. The Mi-26 was perhaps the zenith in the illustrious career of Marat Tishchenko, protégé of Mikhail Mil, who founded the design bureau, known as OKB Mil, in the late 1940s. Since its founding, OKB Mil has developed 15 helicopter types and 200 variants. By 1999, Mil had produced more than 30,000 helicopters, accounting for one of every four in the world.

Tishchenko joined the OKB as an engineer in 1956 and advanced through increasingly key engineering roles until he became the head of the design bureau upon Mil's death in 1970. Soon after, the Mi-26 project was launched.

I first met Tishchenko at the University of Maryland several years ago. Now 75, he is a tall, lean, soft-spoken man with bushy white eyebrows and white hair. He comes to the university four months every year to advise students on an American Helicopter Society-sponsored competition, one that the school has won every year since 1998, when Tishchenko signed on. Sometimes I would spot him in the hall outside his of-

[ BIGGEST HELICOPTER ]

## Running the Numbers



The Mil Mi-26 has been the world champion of rotary-wing heavy lift since it debuted in 1980.

**Length:** 111 feet

**Rotor diameter:** 105 feet

**Total shaft horsepower:** 22,800

**Payload:** 20 tons

**Gross weight:** 56 tons


ANDI DUFF/ALAMY

**Parachutists delight in jumping from rare aircraft. These Space Boogiers proudly noted an Mi-26 jump in their logbooks.**

fice, pacing back and forth, leaning forward as if fighting a headwind, hands clasped behind his back, oblivious to his surroundings.

The primary role of the project he led was military—in particular, carrying a 28,000-pound amphibious armored personnel carrier—but the Mi-26 was also designed to meet a civilian requirement for airlifting bulky cargo. According to *Jane's*, about 300 Mi-26s have been built, and a few dozen have been exported to as many as 20 countries, including Belarus, Cambodia, the Democratic Republic of the Congo, India, Kazakhstan, North and South Korea, Mexico, and Peru.

Back in Afghanistan, Chuck Jarnot found an outfit through the Internet, Skylink Aviation in Toronto, that claimed to have access to a civilian Mi-26. Skylink had connections with a Russian company, Sportsflite, that owned three Mi-26T civilian versions it called Heavycopters. One, based in Tajikistan, was doing construction and firefighting work but could be flown south to Afghanistan to do Jarnot's bidding for about $300,000.

Jarnot's request was run-of-the-mill for the people who operate Mi-26s in civilian heavy lift, where just about every job is an oddball. In October 1999, an Mi-26 was called in to haul a 25-ton block of ice encasing a nicely preserved 23,000-year-old wooly mammoth from Siberia's tundra to a lab in Khatanga, Siberia, where scientists were eager to study and to perhaps try cloning the find. Thierry Lakhanisky says he heard through the grapevine that the load was so great the helicopter had to be returned to the factory immediately after the lift to check for structural excesses that could have warped the airframe and rotors. Lakhanisky himself has used an Mi-26 to haul immense silos and towers for industrial customers and, in 1997, a pack of 125 skydivers during an international skydiving "boogie" in Vichy, France.

Everyday jobs include humanitarian work—last February, Russia had three Mi-26s delivering supplies to earthquake victims in Pakistan—as well as hauling equipment for firefighting, logging, mining, and oil exploration. John Lazzaretti, vice president of marketing for Columbia Helicopters in Oregon, worked alongside a Skytech Mi-26 in the oil exploration business in Papua, New Guinea, in the early 1990s. He recalls the first time he saw the behemoth flying out of Port Moresby, its internal hold loaded with graders or dump trucks destined for remote drilling sites for Chevron. Particularly impressive was the technique used to get airborne: Lazzaretti says pilots would tilt the helicopter up on its nosewheel and roll forward on the 200-foot landing strip, gaining speed until descending out of sight into the valley below. "Pretty soon you'd see it start to rise up," he recalls. "You could almost count the blades going by."

The Mi-26's size was not merely the embodiment of a "bigger is always better" mentality but the result of sound engineering principles. Its family tree took root in 1953, when the Soviet military tasked OKB Mil to come up with a rotorcraft that could carry 25,000 pounds over 150 miles. The result, the Mi-6, was at the


© TASS/SOVFOTO

**Like the whale and Jonah, an Mi-26 swallows a truck without so much as a belch.**

SGT. JUAN VARA/USMC


CRAIG MURRAY

**U.S. heavy lifters include the Sikorsky CH-53E Super Stallion (left, prepping to haul out a Russian tank in Iraq), and the Sikorsky S-64 Skycrane (in firefight mode in Australia).**

time the largest production helicopter in the world, with a total weight of nearly 90,000 pounds, more than 16,000 pounds heavier than the CH-53E. Code-named "Hook" by NATO, the Mi-6 set several records; for instance, achieving 211 mph on a closed-circuit course.

In addition to its military applications—including recovering Soyuz spacecraft capsules after they parachute to Earth—the Hook was key for civilian oil exploration in western Siberia. Tishchenko says it was the first helicopter to include a rear door for loading and an electrical de-icing system for the rotors. Though the project got started before Tishchenko joined the bureau (he was still in school), he knows enough about it to characterize it as "extremely advanced" at the time. Igor Sikorsky's son Serge told Tischenko that his father called the Mi-6 "not one step forward, but two steps forward" in rotary-wing technology.

If the Mi-6 and, by association, the Mi-10, a long-legged flying crane version, were two steps forward, then the next iteration in heavy lift was one giant leap. In 1960, after most of the design challenges of the Mi-6 had been conquered, the Russian military asked Mil to build a monstrous heavy lifter with double the cabin space and payload of the Mi-6, then the world's largest and fastest production helicopter. The primary purpose was to move military equipment and mobile intercontinental ballistic missiles to remote locations after handoff from an Antonov An-22 transport.

At Mil, where Tishchenko would become second in command of the project, under Mil himself, engineers did numerous configuration studies from 1960 to 1964 for what they would call the V-12 helicopter. They ultimately chose a side-by-side rotor configuration over a tandem-rotor, a three-rotor design, and even a ramjet-powered version with the engines on the tips of the rotors. (U.S. inventor Stanley Hiller experimented with a similar design in 1948.) To speed up development and minimize surprises, the Mil team used as many Mi-6 components as possible, including the engines, rotor, and power train and control parts.

Mil built two V-12 prototypes, the first in 1967. The company made more than 150 test flights, and in August 1969, the craft set a world record—lifting 88,636 pounds to an altitude of 7,398 feet. The second prototype was displayed at the Paris Air Show in 1971, the same year the project was cancelled. "When the tests got to the end, no missile," Tishchenko says. Nonetheless, the experience of building a highly stable twin-rotor helicopter with a maximum weight of nearly 215,000 pounds, capable of carrying a 61,000-pound payload, would prove priceless for what lay ahead for Tishchenko.

His next project, starting in the early 1970s, was to rejuvenate the Mi-6 design while doubling its lifting capacity. The result was the Mi-26 (called Halo by NATO). Now head of the design bureau and in charge of about 5,000 employees, Tishchenko had planned on using Mi-6 components for the new helicopter. He


**A matched set of Mils taxis among wildflowers in Marseille after a French firefighting mission in the summer of 2003.**

soon realized, however, that "to achieve the required performance of the helicopter, its components should use the latest achievements in their design," as he wrote in a technical report on Mil heavy lifters in 1996. Tishchenko ultimately selected a single-rotor configuration powered by two 11,400-shaft-horsepower Lotarev D-136 turboshaft engines. The key to making it work was to produce a transmission light enough but strong enough to deliver all that power to both main and tail rotor, a feat the Mil bureau accomplished in-house. On February 21, 1978, the Mi-26 made its first flight.

Twenty-four years later, Jarnot and the U.S. military would be the beneficiaries of the immense amount of engineering work that went into Mil's heavy-lift helicopters. Six weeks after Jarnot placed a call to Skylink, a Heavycopter Mi-26 showed up to reclaim the Chinook from the mountain. Jarnot says the eastern European crew "snatched it with a hook" and flew it to Kabul, then later to Bagram Air Base in Parvan, Afghanistan, for shipment to Fort Campbell in Kentucky for repairs.

Six months after that, Jarnot, as the security force task manager at Bagram, attended a meeting where Army officials regretted having to dissect an Army CH-47 Chinook that had made a hard landing about 100 miles north of the base at a 4,000- foot elevation. The Army had considered lifting the damaged aircraft back to base with a CH-47D and a CH-53, but both proved incapable of the lift. "Why not use an Mi-26?" Jarnot recalled saying, a suggestion that was met with laughter and snickers. When he added "We did this six months ago, General," the room fell silent. Soon after, using Jarnot's contacts in Canada, the Army welcomed another Heavycopter to Bagram, this time paying $350,000 for the job.

**At the 1992 Farnborough Air Show in England, an Mi-26 took center stage to show off its prodigious water drop capability.**

© TASS/SOVFOTO


© PERSON EMMANUEL

The snickers weren't unusual for people who come from countries like the United States, where experience with Russian aircraft is limited. Only a handful of Mils operate in the United States, and the Mi-26 is not among them.

Operators familiar with Mil helicopters, on the other hand, say that the equipment is quite safe and reliable, but that the parts often have shorter lifetimes than Western or European equipment. Getting the parts and the people to install them seems to be the biggest challenge. Columbia Helicopters' Lazzaretti recalls that when an Mi-26 had mechanical problems in New Guinea, the operators found themselves in negotiations with maintenance experts in Russia, discussing how much it would cost to bring them to New Guinea to fix it. "When they were down for maintenance, they were down for weeks," he says. "The Russian attitude was 'We built these things to be put out in the field; if anything goes wrong, kick it off to the side and get another.'" In the early 1990s, Columbia had considered teaming with a Russian company to bring Mils to the United States, but ultimately decided against it. "The Russian equipment is powerful stuff; it's well built," Lazzaretti says, "but if we can't have the parts control to keep them flying, we're not interested in having them."

Tishchenko thinks one of the reasons the Mi-26 hasn't made it here is that U.S. helicopter manufacturers don't want the competition, a particularly pertinent notion when it comes to the U.S. military's new Joint Heavy Lift program. The military wants a helicopter that can lift a minimum of 40,000 pounds for 1,000 miles, and U.S. manufacturers would like to build an aircraft to fill that role. Though the requirements are slightly beyond what the Mi-26 can handle, Tishchenko thinks the goals are surely within the realm of an enhanced Mi-26, a product he continued to work on as a consultant with Mil after he retired in 1991.

Its capabilities, says Jarnot, make the Mi-26 the 800-pound gorilla in the room any time Joint Heavy Lift programs are discussed. Of course, at this point Jarnot's a bit biased, having twice seen the unequalled strength of the Mi-26 and, more recently, having met its designer. After attending a lecture Tishchenko gave in Philadelphia last summer, Jarnot managed to get seated next to him at dinner. He pulled out his pictures of the MH-47E rescue in Afghanistan. One of those pictures is now in a frame on a wall of Jarnot's home—autographed by Tishchenko.

How Things Work:

# Phased-Ar

BY SAM GOLDBERG | ILLUSTRATION BY JOHN MACNEILL

**AT 282 FEET IN HEIGHT, TWO FOOTBALL FIELDS IN AREA, AND 50,000 CUBIC TONS IN VOLUME, THE SEA-BASED X-BAND RADAR INSPIRES DESCRIPTION IN THE MOLD OF "YOUR MAMA" JOKES: SBX IS SO FAT IT COULDN'T FIT THROUGH THE PANAMA CANAL. SBX IS SO TALL IT COULD STRADDLE THE GOODYEAR BLIMP. SBX IS SUCH A SUPERSTAR, IT HAS ITS OWN SELF-PROPELLED, SEMI-SUBMERSIBLE OIL-DRILLING PLATFORM AS A RIDE.**

The near-$900 million structure, operated by the U.S. Missile Defense Agency (MDA), is by far the largest phased-array radar system on Earth. It is 16 times more powerful than the previous champ—its own prototype—and capable of determining if a baseball-size object thrown into space from another continent is a slider, a curve, or a knuckleball.

This summer it will leave Pearl Harbor, where it is being painted, and voyage to its home port of Adak, Alaska, for the first time. After being integrated into the battle management systems of long-range interceptor missiles located in Alaska and California, the SBX will be able to move throughout the Pacific Ocean, or anywhere else it's welcome, for training or actual defensive operations.

Once active, it will identify enemy missiles outside the atmosphere, at the highest point of their ballistic trajectories, so that the interceptors can take them out.

With the same frequency of radiation that your microwave oven uses to warm Lean Cuisines, SBX probes the nooks and crannies of "threat complexes"—the cloud of warheads, decoys, and debris such as loose nuts and bolts, spent booster stages, and unburned fuel that surround an enemy missile.

"We can differentiate between very tightly spaced objects, small and large objects, and the like," says Army Colonel John Fellows, MDA's project manager for X-band radars. "We can tell [which] is the threatening object."

At the frequencies used by X-band radars, ranging from 8 to 12 gigahertz, relatively short wavelengths enable sharp, high-resolution radar images.

"You might be able to see rivets and seams and joints and fins, and [that] allows you to form a very accurate representation of what is there," says Larry Briggs, who as Raytheon's program director for ground-based radars oversaw the design and construction of the SBX's radar array.

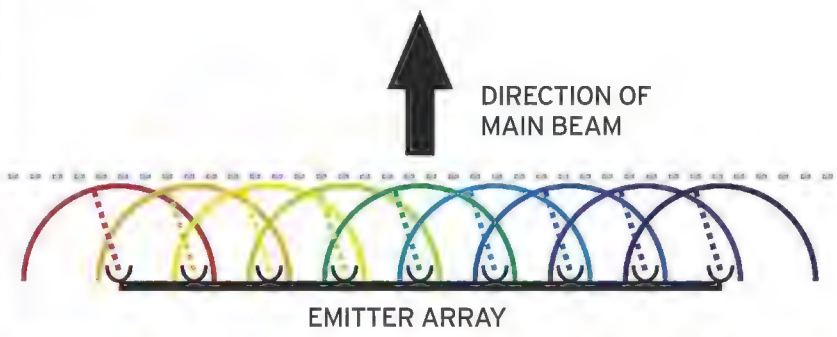
Before catching a ride to Hawaii on the back of the *Blue Marlin*, the world's largest cargo vessel (which had to be widened for the job), the SBX spent the summer of 2005 on a 52-day shakedown cruise in the Gulf of Mexico. After the platform outran hurricanes, it tested its 10-story array by turning it skyward to track satellites.

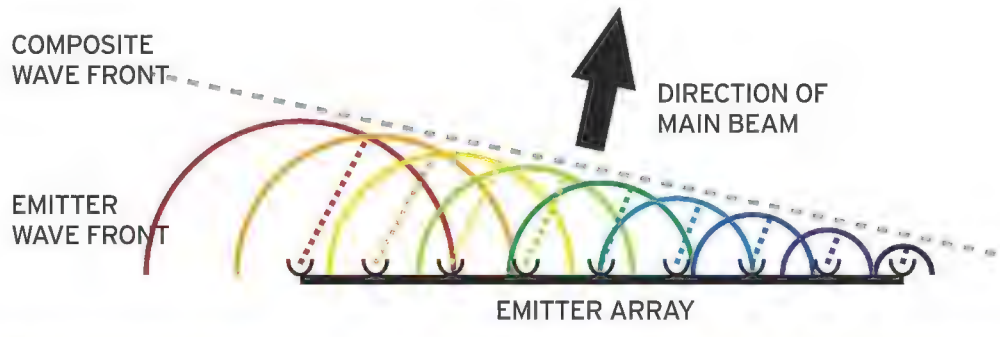
Like all radars, the SBX works by broadcasting a pulse of radio waves, then watching for the reflections. The radio waves are produced by tiny antennas called radiating elements. SBX has roughly 45,000.

Radio rays build upon or cancel each other when they cross paths. But just how waves interfere with each other depends on the phase of each contributing wave—whether the wave is at its crest, its trough, or somewhere in between.

A map of the interference between radio waves is called a radiation pattern. It is the radiation pattern that allows one to see where waves constructively overlap and where waves destructively overlap to cancel each other. The main beam is formed at the line where the greatest number of waves projected by the radar emitters constructively overlap to form a composite wave front.

**The main beam is steered by overlapping the crests of radio waves, allowing a composite wave front to quickly sweep back and forth.**



# ray Radar


BOEING

**The SBX, shown here on a cargo vessel in Texas, practiced two days of "weather avoidance" when Hurricane Emily arrived in the Gulf of Mexico during 2005 testing. The range of the array inside the dome is limited only by Earth's curvature.**

A conventional radar tracks targets by physically turning its main beam 360 degrees and then measuring how reflective items—"blips"—have moved since previous sweeps.

But phased-array radars work differently; they steer the main beam by manipulating the pattern emanating from an array of hundreds or thousands of radiating elements, nearly instantaneously moving the location of the overlapping waves instead of an actual dish.

"You don't change [the antenna's] properties when you scan," explains Larry Corey, chief engineer of Georgia Tech Research Institute's Sensors and Electromagnetic Laboratory. "You just change how the energy from every one of those elements adds up either constructively or destructively."

To point the SBX's powerful main beam, computers command each of its radiating elements to slightly shift the initial phase of the radio waves they shoot.

Thus, each element emits a radio wave with crests and troughs that are slightly out of sync with the crests and troughs of the radio waves emitted by its neighbors. For example, a wave being radiated from element A may start at a crest, while the wave emanating from element B begins life as a trough.

The effect is that the beam swings from the center to the right or left (see diagram, opposite). With the new elements added, the beam can be pointed up or down as well. The direction of the beam can be changed in 20 microseconds or less.

The main advantage to this approach is that the radar can keep a constant eye on a target—it can shoot and watch for radio reflections thousands of times per second instead of going blind until the next rotation sweeps the main beam past the target again.

Since the main beam can be pointed almost instanteously, it can jump from object to object as they come into range.

Phased-array radars are not without disadvantages. Most are functional through a cone of just 120 degrees, because the width of the main beam diminishes the farther it gets from broadside. As an example, think of how narrow your widescreen television looks when you're in an adjacent room.

For this reason, at least four radars are needed to cover a hemisphere. To compensate for the narrow field of view, the SBX's main array rotates and tilts; it's one of the few phased arrays to do that.

Although the initial cost is 100,000 times more expensive than a conventional radar with the same beam width, a phased-array device may be cheaper long-term because the system will still function as needed even if many of its smallest components fail.

# the Beaver and the Swans

A tricked-out de Havilland classic is the best perch for counting the heavies of the bird world.

by James Wynbrandt

Photographs by Clark Mishler

# "Pair at two o'clock."

Flying at 500 feet, pilot and biologist Bruce Conant looked in the direction I called and banked the de Havilland Beaver toward the swans on the lake a mile away. We were flying as part of a month-long U.S. Fish and Wildlife Service project to study the Alaskan population of trumpeter swans before their annual migration south. Throughout last August, 14 aircraft flying up to eight hours a day would scour some 50,000 square miles of habitat, the largest attempt in the world, project managers believe, at an exact census of wildlife. Our job was to record the location of each sighting and tabulate the number of adults and young in every brood. With wildlife survey flight time in my logbook, I was on board as a volunteer observer.

A flyby of the swans on the lake yielded no sight of the young, called cygnets, whose tell-tale gray makes them hard to see from a distance. Using a knitting needle as a stylus, I input the pair of swans' position on the touch-screen map, a digitized, GPS-linked version of U.S. Geological Survey maps we used to navigate and to record sightings. From the tabulation subscreen that appeared, I selected a "P" (for "pair") and confirmed the entry. Had there been cygnets, I would have input their number.

We were flying into the Susitna Valley. On three sides of the lake, peaks of the Alaska Range rose, squeezing the northern end of the valley into nothingness, but Conant is a veteran of tight spots. After 30-plus years of bush flying, not much rattles him.

We were hoping for cygnets. Earlier discussions among observers had come to the dispiriting conclusion that many of the fledglings were undergrown, and probably wouldn't be strong enough for the flight south. "You wonder what goes through the minds of those swans," Conant said. "They must know the cygnets aren't going to make it. I guess they don't give up until the very end."

Named for its call, the trumpeter swan, *Cygnus buccinator*, is one of the world's largest flying birds, with weights up to 35 pounds and wingspans reaching eight feet. Once hunted for food and feather, by the turn of the last century they were thought extinct, victims of the slaughter of species that led to federal regulations to protect the nation's wildlife. The Fish and Wildlife Service has monitored swan populations since the 1930s, when several dozen trumpeter swans were discovered in Yellowstone Park. In 1954 a population in the hundreds was found in southern Alaska.

Their size, magnificence, and brush with extinction have made trumpeters avian celebrities, and in addition to the protection of law, they enjoy the support of an organized advocacy group, the Trumpeter Swan Society. The society supports research into the

**Quadrant by 15-square-mile quadrant, a turbine-powered de Havilland Beaver (opposite) and 13 other aircraft scoured the state of Alaska last August to count trumpeter swans. The swans spend late summer in this intermediate habitat before flying to the lower 48 for the winter.**

The author looks through the de Havilland's broad windshield for the tell-tale flash of white.

"Fifty years and still counting" is the survey's motto; its logo (above) shows spotter and spottee. Under the Pinocchio nose of N754, Julian Fischer, Jack Hodges, and Debbie Groves check tabulations.

sources of the lead that has poisoned thousands of the swans in the Northwest in recent years and pays close attention to the results of the aerial census, conducted every five years.

The swans' anti-camo plumage is a great help to the census-takers. Occasionally a flash of brilliant white will warrant a closer look, usually to reveal itself as a bit of wind-whipped lake foam, sunlight reflecting off a rock, even a sun-bleached moose rack. But for the most part the adult swans are unmistakable and hard to miss, whether on a cobalt-blue alpine lake or nesting in the green reeds encircling a glacial pond.

The survey is alternately exhilarating and monotonous. In high-density areas, where it seems every one of the endless lakes has at least a pair, the project has the feel of a cattle roundup, as we cut and wheel one way, then another. But in some USGS quadrants, the terrain in the 15-mile square is unchanging and devoid of trumpeters, and an hour or two without a swan is enervating and mildly depressing, no matter how magnificent the scenery.

Fish and Wildlife Service crews and aircraft typically operate in remote areas, and sometimes eddying rivers, small lakes, or unimproved strips are their only airports. In this roadless environment, the air crews have adapted strategies ranging from packing extensive survival gear aboard to modifying both airframe and powerplant. The queen of the modified fleet is N754, the one-of-a-kind de Havilland DH2 Beaver that Conant flies.

N754 was modified in 1976, when Jerry Lawhorn, then the aviation manager of the Fish and Wildlife Service's Alaska region office, worked with Volpar Inc. of Van Nuys, California, to customize the aircraft for aerial surveys. On one of the many days last August when we couldn't fly because of low ceilings, Conant and I dropped in on Lawhorn at his home in Anchorage. A picture of N754 hung on the wall opposite the front door. In the living room, Lawhorn joked about the oxygen canister he had to carry around, referring to his "range between refueling." Settling into a couch below a pair of bighorn sheep trophies, Lawhorn recalled spending hours riding along with survey pilots and watching how they operate so that he could explain to Volpar exactly what he needed for counting critters from the air. Lawhorn was no stranger to aircraft design. A pioneer in bush operations, he had designed and built his own airplane shortly after arriving in Alaska in the late 1940s.

For wildlife surveys, Lawhorn needed an aircraft that was simple to operate and had superb forward visibility. Most turbine-powered Beavers use a Pratt & Whitney PT-6 engine, but that engine's exhaust stacks, exiting from the side, interfere with an observer's view. Volpar had been converting Grumman Gooses from piston engines to 715-shaft-horsepower Garrett 331-2UA-203D turbines. Hoping for a military contract to do the same for de Havilland Beavers, the company was happy to work with Lawhorn to make a single example of what it hoped to produce in large numbers. Lawhorn was interested in the Garrett engine because its exhaust exits from the bottom and doesn't interfere with the pilot's visibility. That engine is what gives N754 its distinctive needle-nose nacelle. Except for narrow frame posts, the windshield provides unobstructed front-to-side observing. And on the instrument panel, switches, power levers, and handles have been repositioned for simplicity of operation.

"It had to be biologist-proof," Lawhorn said. Every Fish and Wildlife Service pilot-biologist has a baccalaureate in biological sciences, a minimum of 500 hours of flight time, and an instrument rating. Beyond that, some come with more experi-

ence in biology than in aviation.

An aircraft that has been as highly modified as N754—different engine, panel layout, and avionics from those aircraft holding the Beaver's type certificate—would ordinarily have to go through a series of certification tests to win approval from the Federal Aviation Administration. But the airplanes that fly the aerial surveys come under the purview of the Department of the Interior, and they fly with waivers from the department's Office of Aircraft Services.

No survey airplanes were flying near Fairbanks in mid-August. Crews had been grounded by smoke from forest fires. When rain had finally cleared the smoke from the state's interior and crews were airborne again, I went surveying with Karen Bollinger in a Cessna C-206 near the confluence of the Tanana and Yukon Rivers, some 100 nautical miles west of Fairbanks. It was here that one of the first references to Alaska's trumpeters was recorded: In 1870, a traveler noted the greased locks of the Tanana Indians "powdered with swan's down, cut up finely...presenting a most remarkable and singular appearance."

Even then trumpeters were scarce, which makes the resurgence witnessed from the air over the last three decades remarkable, according to the biologists in the Fish and Wildlife Service. The first aerial survey, conducted in 1975, counted 4,170 trumpeters. By the 2000 census, the total reached 17,155.

Brood size is the key to the swans' future, so an accurate tabulation of the young is important. Their tendency to huddle together makes the cygnets hard to count from 500 feet. Over one such brood, Bollinger pulled the power, extended flaps, and made a dive-bombing turn for a closer look. The swans seemed not to notice the airplane. Sometimes multiple passes are required. (Observers are judged largely on their ability to endure these gut-wrenching maneuvers without puking.) I was lucky; on our first pass I could clearly see four cygnets following their parents into the water.

By the end of August, N754 was operating out of Bettles, north of the Arctic Circle, along with a C-206 that carried bio-pilot Jack Hodges and observer Debbie Groves. The census was in an accelerated dash to the finish. Groves would soon begin to tabulate the data.

Once the database is complete, it will provide information for land use planning and policy decisions. Placement of power lines, establishing boundaries of wildlife refuges, issuing permits for mining operations—all have been influenced by the results of previous surveys.

This year's final count was higher than expected: 24,105. But for all the concern about the trumpeters' future, it's the census and the Alaska region's unique aircraft and operations that seem most endangered. At $229,000, the survey's cost about equalled the region's 25 annual counts of other wildlife combined. The Fish and Wildlife Service tracks other migratory birds as well as sea otters, moose, and bears. "I think it's really questionable whether it will ever be done again," said Russ Oates, a biologist and Fish and Wildlife manager in Alaska. "There's been a lot of skepticism about putting this much money into a species that has obviously recovered from its all-time lows."

Oates believes that monitoring the swan populations is still necessary. "We don't want this species to decline again," he said, adding that 24,000 Alaskan trumpeters plus the few thousand elsewhere are relatively small numbers for the worldwide population of any animal.

"I can tell you I'll be here in 2010, and I'll be putting in a proposal," Oates said a moment later. Like the trumpeter swans, the census takers know a thing or two about fighting for survival.

**Top (from left): Bill Larned, Russ Oates, and Bruce Conant plot the next segment of their swan search.**

**Bottoms up! Swans spend their time in Alaska bobbing for roots and resting up for the long flight south.**


# Take Two

## THE ART OF RE-CREATING WORLD WAR I.

*by Tom LeCompte | Photographs by John Dibbs*

Modern-day England plays the lead in *Flyboys*, pretending to be the rolling green hills of World War I France. A fleet of Nieuports—some refurbished vintage aircraft and others full-scale, non-flying mockups—as well as "airmen" re-create the Lafayette Escadrille. Right: Young lead James Franco glares moodily from the cockpit of his Nieuport.

**A NIEUPORT 17 BIPLANE** is skimming over the countryside, weaving between ancient oaks, buzzing meadows, and bobbing over the occasional sheep. The 110-horsepower radial engine groans as the pilot pulls the airplane into a tight turn, dipping the wing under the bough of a giant tree.

One could imagine that it's 1917, that the rolling landscape is French farmland, and that the Nieuport is piloted by one of a select few Americans who, even though the United States is a neutral country, has volunteered to fly for the French against the Germans.

But the spell is broken by the sound of a jet-powered helicopter not 40 feet from the Nieuport's tail.

The Nieuport is not the French-built fighter that helped end Germany's domination of the air during World War I, but a recently built replica; the countryside is not French, but English; and the pilot is not a World War I ace; he's Andrew King, a native of upstate New York who, between 1982 and 1986, flew World War I-vintage aircraft at New York's famous Old Rhinebeck Aerodrome.

As the helicopter chases his Nieuport, King hears a familiar voice in his headset: "That's great. Let's go around and do it one more time. Only this time, can you make it lower?"

Welcome to the set of *Flyboys*.

The first movie torealistically portray World War I aviation since Jack Gold's *Aces High* in 1976, *Flyboys* is based loosely on the experiences of the volunteers who made up the Lafayette Escadrille. The privately funded flying squadron comprised 38 wealthy young Americans who were anxious to enter the war in support of the Allies. In 1917 and 1918, the group shot down 57 aircraft, and was used as a valuable propaganda tool in getting the United States to fully enter World War I. The film stars famous French actor Jean Reno, and a lesser-known young American, James Franco. Set for release in October, *Flyboys* will, its producers promise, thrill its audiences with aerial stunts and dogfighting. More to the point, it will do so using real airplanes and real flying.

Increasingly, technology has made real airplanes obsolete in the movies. Audiences who marveled at the swarms of fighters in *Pearl Harbor* (only six of the aircraft in the film were real) or at the flying scenes in *The Aviator* have computer graphics artists to thank. Computer-generated imagery (CGI) has taken over, changing both the way films are made and what audiences expect from them.

When asked to name their favorite aviation films, however, pilots and aviation aficionados typically list classics such as *The Battle of Britain*, *The Blue Max*, or *Those Magnificent Men and Their Flying Machines*—

JAY MAIDMENT, PROPERTY OF ELECTRIC ENTERTAINMENT (2)

**Aerial unit member Tony "Taff" Smith (center) and director Tony Bill (right) review a maneuver with pilot Bob "GG" Gauld-Galliers, who massages his arm after enduring the physical ordeal of flying a vintage airplane.**

movies made in the 1960s and 1970s, before computer-generated imagery took over. To these moviegoers, computer-generated images simply cannot convey the complexity and nuance of real flight.

Director Tony Bill, a 3,500-hour commercial pilot with experience in gliders and aerobatics, first thought about making such a film 30 years ago. In the late 1960s, Bill and aviation writer Richard Bach spent a summer barnstorming in Kansas, giving demonstrations and selling rides in Bach's vintage biplane, a 1929 Parks P2A. A few years later, when Bill was a young producer, he pitched director George Roy Hill an idea that came from his experience: a movie about a couple of former World War I pilots barnstorming around the Midwest. Hill made the movie—*The Great Waldo Pepper*, starring Robert Redford—but without Bill.

"I've wanted to make an aviation movie my entire career," says Bill. And when the chance came with *Flyboys*, Bill insisted that the film rely, at least in part, on real airplanes. Using modern filmmaking technology like miniature "lipstick" cameras and gyro-stabilized camera mounts, Bill would make the airplanes the true stars of this film. But flyable airplanes from the early years of aviation are very rare, and the moviemakers' first challenge was to find enough of them to put together a mock squadron.

The only genuine Nieuport 17 in the world sits in the Royal Army and Military History Museum in Brussels, Belgium. Only replicas still fly, and of the half-dozen available, a majority work the airshow circuit and are booked more than a year in advance. To help round up the aircraft needed, Bill called on Sarah Hanna, who with her father, Ray, a former airline pilot and once the leader of Great Britain's Red Arrows aerobatic team, has run a museum and airshow business, the Old Flying Machine Company in Duxford, England. (Ray Hanna died last December.)

Bill also turned to Mike Patlin, who had worked as an aircraft provider and aerial coordinator on several film productions. Patlin introduced Bill to Ken Kellett and Andrew King, two pilots who probably

**Above: Heading down the grass runway, a Nieuport 17 (with its pilot in full costume) brings the past to life. Opposite: A Eurocopter AS-350 was often only feet away from the Sopwith Strutter 1 1/2 it was filming.**

have more experience with early aircraft than anyone else in the United States.

In addition to his Old Rhinebeck background, King, a tall, friendly man who has a taste for adventure, works on vintage aircraft at his airplane repair and restoration business in Virginia. He has 2,750 flying hours (all but 200 of which are in vintage types) in 100 types of vintage aircraft. His earliest memory, he says, "is of Cole Palen's Nieuport 28 being run up on the ground, with three or four guys on each wingtip holding it back."

Kellett, a youthful-looking man in his 50s with a laid-back, chatty manner, started flying at 15. He's flown about 50 types of airplanes, a dozen of which were vintage, and been involved in 45 restoration projects. He also has the distinction of having built and flown a full-scale replica of the earliest aircraft. For the 75th anniversary of the first powered flight, Kellett flew his Wright *Flyer* replica in front of a crowd of 10,000 at Kill Devil Hills in North Carolina, and landed on the front page of nearly every major newspaper in the country. "I have four minutes total time [flying the airplane]," says Kellett. "And I couldn't look you in the face and say that I ever truly had the airplane under control. You get on it, ride it, and hope you don't get hurt in the end."

Today Kellett is a restorer at the Fantasy of Flight museum in Florida, owned by pilot and collector Kermit Weeks. For years visitors to the museum were greeted by a Nieuport 17 replica suspended over the museum entrance.

Weeks agreed to have the replica removed for use in *Flyboys*, but the airplane, built in 1971, was unflyable. Once Kellett got it down from the ceiling, he discovered it needed a new engine, firewall, tail skid, control cables, and fabric covering.

In just six weeks, Kellett managed to complete the job. He called on King to help work out the bugs in the new engine and to flight test the airplane.

In the meantime, Kellett was tasked with tracking down a two-seat fighter. He knew of a replica two-seat Sopwith 1 1/2 Strutter for sale. Built in 1915, the Strutter was a forerunner of the famous Sopwith Camel. The Strutter replica, built in 1992, was part of a private museum in

**A technician lifts the heavy camera into its gyrosphere mount on the front of the Eurocopter.**

Guntersville, Alabama, whose holdings were being sold off.

"[The Strutter] had never been flown," says Kellett. "The FAA saw it on Friday, we test flew on Saturday for [the required] five hours...tore it apart Sunday, and shipped it to England on Thursday."

In addition to the Strutter and Weeks' Nieuport 17, Patlin and Sarah Hanna put together a fleet that included another Nieuport, two German Fokker DR I triplanes (made famous by German ace Manfred von Richthofen, the "Red Baron"), a British Bristol F-2 fighter (of the first six of these biplanes built, four were shot down by von Richthofen on the Western Front in 1917), a French Blériot XI, and a Royal Aircraft Factory SE-5a. The fleet was still short. To make sure there were enough airplanes to fill the takeoff and landing shots as well as backups, Bill wanted at least four more Nieuports. Patlin called Robert Baslee, of Holden, Missouri, who builds full-scale replicas of vintage aircraft using techniques of ultralight aircraft builders. His replica, made with aluminum tubing and a Volkswagen engine, weighed less than half what an actual Nieuport does, but Baslee promised the airplane had comparable performance. Baslee started in December 2004; in 52 days, he built four Nieuport replicas.

**The Fokker DR I triplane played two roles in *Flyboys*. Each day, the film's special effects crew undressed the antique German airplane (left), stripping off its costume of red latex paint and turning it back into a more menacing black version (above).**

Primary shooting with the actors began in April at the Royal Air Force Halton base, outside London, where set designers created a full-scale mockup of a World War I aerodrome, complete with huge canvas hangars, a machine shop, a canteen, and assorted period vehicles. Full-scale but non-flying mockups of Nieuports, Sopwiths, and Fokkers were built to fill out the flightline.

One of the major challenges in filming *Flyboys* was finding locations appropriate for the time period, devoid of modern buildings and roads. And the landscape had to look like France. The Lafayette Escadrille was based in Chaudun, northeast of Paris, near the German border.

For the most part, these limitations led to filming at national parks or grand old estates. The producers got lucky when the British army gave them permission to film at the 30,000-acre Stanford Training Area, carved from a section of East An-

JULIE APPLEBY

**Andrew King (the hero's stunt double) poses with his Nieuport 17 (the hero's aircraft) before taking off to film an aerial run-in with the evil Black Falcon. Only a few seconds of his hair-raising, uphill-with-a-crosswind takeoff made it into the final cut of the movie.**

glia in 1942 as part of the preparations for the Allied invasion of Europe. In the construction of the military range, the government evacuated six villages, leaving them perfectly preserved in their 1942 condition (which could double for 1917 in a pinch, especially from a few thousand feet up).

With the fleet of aircraft in place on a set that created a believable illusion of 1917 France, Bill and the pilots were ready to re-create World War I aerial combat.

"In researching *Flyboys*," says Bill, "I came across some amazing footage of early aerial stunts—crashing real airplanes into real houses, into lakes, into trees. [There was] one incredible stunt of a pilot stalling and spinning his plane into a barn." But Bill wasn't looking for stunt flying; "I wanted aerial combat circa-1917, a very different form of aerobatic and reckless flying."

There is no existing footage of aerial combat in World War I. Bill and his screenwriter David Ward created scenes from 1917 based on their imaginations. "The [flying sequences] were written by David first as part of our story, not as reproductions of any particular event," says Bill. "This is not a documentary."

On the set of *Flyboys*, safety was paramount. "Our pilots wore chutes, but I dreaded any of them trying to get out of

## Hollywood Has Always Loved the Airplane

***Hell's Angels*** (1930)
**Director:** Howard Hughes
Howard Hughes' infamous film about two Royal Air Force pilots in World War I was an enormous undertaking—and ended up killing several of the stunt pilots. The film is rife with fantastically daring flying sequences.

***Devil's Squadron*** (1936)
**Director:** Erle Kenton
As test pilot deaths mount, a young woman is forced to close her late father's aircraft manufacturing company.

***Test Pilot*** (1938)
**Director:** Victor Fleming
Clark Gable is a daring test pilot, Myrna Loy is his love interest, and Spencer Tracy is his trusty mechanic.

***Twelve O'Clock High*** (1949)
**Director:** Henry King
Real combat footage was used in this film about a bomber squadron flying over Germany in World War II.

***Flight of the Phoenix*** (1965)
**Director:** Robert Aldrich
A plane (piloted by Jimmy Stewart) crashes in the middle of the Saharan desert, stranding everyone on board. It takes a guy who builds model airplanes to piece the fuselage back together. Stunt pilot Paul Mantz was killed when he tried to land the C-82, the airplane they were using as the *Phoenix*. A passable 2004 remake stars Dennis Quaid and Giovanni Ribisi.

***The Blue Max*** (1966)
**Director:** John Guillermin
George Peppard plays a foot soldier in World War I who becomes a fighter pilot and does his best to win the Blue Max, a medal bestowed on aces with 20 kills.

***Tora! Tora! Tora!*** (1970)
***Director:*** Roy Fleischer
The United States and Japan get equal blame in this interesting account of the events leading up to Pearl Harbor.

***The Great Waldo Pepper*** (1975)
**Director:** George Roy Hill
Robert Redford plays a barnstormer who missed out on being a World War I flying ace and can't quite get over it. There's no computer-generated imagery in this film—all of the flying and the airplanes are real.

***Aces High*** (1976)
**Director:** Jack Gold
The air war on the Western Front of World War I was brutal. This story focuses on one British pilot fighting the Germans.


INSET: COURTESY ALLEN AIRWAYS MUSEUM/PRIVATE COLLECTION OF WILLIS AND CLAUDIA ALLEN

**A handsome test pilot saves the day in this 1936 film.**

***The Right Stuff*** (1983)
**Director:** Philip Kaufman
Based on Tom Wolfe's book about the original Mercury 7 astronauts, Chuck Yeager, and all of their egos.

***Top Gun*** (1986)
**Director:** Tony Scott
Tom Cruise portrays a hotshot F-14 pilot in this story about a class of new recruits at Top Gun, the Navy's fighter pilot school for "the best of the best," then located in San Diego, California. Renowned aerobatic pilot Art Scholl was killed during the filming—the movie is dedicated to him.

***The Aviator*** (2004)
**Director:** Martin Scorcese
Leonardo DiCaprio plays mad-genius-aviator Howard Hughes in this biopic. All of the flying scenes are done with models or computers.

### FIND OUT MORE

For a more complete list of aviation movies, visit our Web site. We dug up 29 aviation-theme films in total: Do you have any particular favorites? Did we forget any? Let us know!

those tiny cockpits in time to deploy them," he says. "Several pilots died making movies like *Hell's Angels*, [and] no movie is worth death or even injury."

For the pilots, flying the antiques was physically hard work. Though the radial engine replicas are easier to fly than the rotary engine originals, early fighter aircraft are notoriously tricky and unforgiving. The controls are heavy and imprecise, requiring constant adjustments by the pilot and absolute concentration, particularly in low-level flight or tight formation. Pushed to their limits by the demands of the airplanes and the director's quest for the perfect shot, the pilots returned after two hours of airborne shooting stressed out and sweaty, their arms sore; sometimes they were so exhausted they could climb from the cockpit only if someone helped them.

The flight sequences filmed early on were relatively simple: basic shots with the actors, takeoffs and landings, and formation flying. "We did a lot of taxiing in those first few weeks," says King, who arrived in early May, along with Kellett and most of the other stunt pilots.

The dogfighting sequences were done later, and for the most part, those were computer-generated.

"I don't think we ever got 100 feet off the ground," says Kellett. "My flying [in the Sopwith Strutter] was right on top of the water and right around trees. It scared the crap out of me."

**Ken Kellett looks out from under the wing of the Sopwith 1 1/2 Strutter he restored in record time.**

Some tension emerged on the set when it came to melding the working style of aviation people versus that of movie people. Aviators typically plan ahead and keep to a schedule. They don't like surprises. Movie productions make a schedule, then another, then another, then say "Hurry up and do this right now!" Numerous times, the pilots on the aerial unit set their alarms to be on set for 8 a.m. shoots, only to wait around most of the day while the film crew tried to figure camera placements or tweak shot sequences.

In addition to the interminable waiting, the frequent changes, and the unpredictability, there were breakages and mishaps—snapped tail skids, bent axles, broken wing spars, ripped fabric coverings, and cracked cylinders. King, Kellett, and the other pilots had to do much of their own maintenance work, often late into the night.

Even make-believe war can be hell.

THE CAMERA PLATFORM for aerial shots was a Eurocopter AS-350 helicopter. The 640-horsepower Ariel turbine engine gave it more than enough power to outperform the vintage airplanes, but to maximize the helicopter's maneuverability, the filmmakers stripped it of unneeded equipment and filled it with only enough fuel to get through each shoot.

"It was white-knuckle stuff," says Kellett. "You really had to pay attention to the helo. The rotor was about five feet behind my tail [at one point]. When he moved in close, I could hear the rotor clicking in my headset. But I kept telling myself *Stay calm and let him do what he's supposed to do.* It was intense."

The helicopter pilot was a Frenchman with the unlikely name of Fred North, who lives in Santa Monica, California. "You have to know what is desired photographically, and what can be done practically and safely," says North of the tricky flying required of him.

While the emphasis in *Flyboys* will be on real airplanes and real flying, the movie will also have plenty of special effects. "Our philosophy was that we'd do everything real that we possibly could do real, and then augment that with other techniques," Bill says. Crashes, explosions, unsafe maneuvers, and—yes, watch for them, purists—maneuvers impossible for real aircraft to perform were all created by computer graphics. And in one case, the computers took over when the real aircraft failed.

During the filming of a formation takeoff with the Baslee ultralight replicas, one of the airplanes lost control shortly after takeoff, pitching up and nearly rolling into another airplane. "They had done the take several times," remembers Kellett, who was on the ground watching the shoot. "It really wasn't a big deal. But the helicopter decided to re-position alongside the runway, and it was amazing how quickly everything fell apart."

The pilots all managed to recover and no one was hurt, but from that point on, the featherweight replicas were grounded. They were too light, too vulnerable, and too difficult to control. For the rest of filming, they served only as set dressing.

Visual effects supervisor Peter Chiang headed up a team of London-based designers that modeled the Nieuport and Fokker airplanes. Thereafter, a scene of the two real Nieuports in flight could be morphed into a flight of four or six. The models could also be tweaked so that they would appear to do things impossible for the real aircraft—snap rolls or vertical climbs, for example.

For many of the aerial sequences, the


**Kellett pilots the Strutter over a typical English countryside, complete with castle.**

directors, without the aircraft in the picture, created background scenery shots (or "plates") that could be used if the filmmakers decided to insert computer-generated aircraft or real ones.

"Like any movie, we use many different tricks," Bill says. In addition to computer graphics, the filmmakers used studio shots of airplanes on gimbals and blue screen (where shots of the actors in cockpits are superimposed over background scenery). In one particular sequence, nearly everything—a German zeppelin and its fighter escorts, the Nieuports sent to thwart it, Paris under siege circa-1917—is computer-generated.

The real trick will be stitching the real and digital together so the whole thing appears seamless. "I've seen the tests," Bill says, who admits he was skeptical at first of how realistic the computer-generated aircraft would appear. "They are remarkable. I don't think anyone will notice the difference."

To those who say such effects smack of fakery, Bill counters, "No one ever filmed aerial combat in World War I. It was technologically impossible. Now it's technologically possible to film many things from the past, from dinosaurs to [Fokker] DR I's. I'll give you an example of something in *Flyboys* that no one has ever seen: In World War I, the aviators used tracers a lot, usually every third round or so, to see where their bullets were going. I read an account of an aerial battle that described the sky looking like 'a cobweb.' Now, you've never seen this effect on screen or in photographs, [but] with CGI we could do it. We could make you see them.

"I can guarantee you this," he continues. "No one, no matter how expert, will be able to pick the real from the CGI planes much of the time. Even I can no longer tell in some of our more populous shots which aircraft are real and which are not.... I really had but one goal: to make the audience feel what it must have been like to fly mortal, sudden-death, hand-to-hand combat in the air almost 100 years ago.

"We had at our disposal a fleet of airplanes that might not be possible to duplicate ever again, and a group of pilots with skills that might not exist a decade or two hence."

And by then, even the actors may be computer-generated.

# Comm

# Thank You For Not Flying | Bryan E.

## A doctor argues that using helicopters as ambulances does more harm than good.

IN A SMALL COMMUNITY hospital in rural Indiana, a 63-year-old man is suffering from heart problems. The treating physician determines that the patient's condition is serious and makes arrangements to move the patient to a larger hospital with more resources and specialists. A medical helicopter is called to make the transfer. No one questions the increased cost of using the helicopter—or the extra risk inherent in flying.

There is nothing remarkable about this scenario. Every day, patients in communities across the United States are transported by medical helicopter. But the 63-year-old patient on this flight didn't arrive at the larger hospital; the helicopter transporting him crashed en route. With the others on board too seriously injured to help him, he strangled to death on a restraining strap. The injured crew and pilot were transported by another helicopter to a trauma center. The National Transportation Safety Board (NTSB) ruled the cause of the accident pilot error; before the flight, the altimeter was known to be malfunctioning.

This disaster is one of 35 medical helicopter accidents that occurred in the United States in 2004 and 2005. Since January 2005, nine crashes resulted in 23 fatalities, a rash of medical helicopter mishaps not seen since the 1980s.

It is widely assumed that medical helicopters provide a significant advantage for patients and save lives. However, recent studies have begun to demonstrate that few patients actually benefit from medical helicopter transport, even during most emergencies. Helicopter transport is appropriate for patients who have conditions that require a time-sensitive intervention, such as life-saving surgery or cardiac angioplasty. These conditions are rare.

Medical helicopters were first used for civilian health care in the 1970s. Initial scientific studies in the 1970s and 1980s indicated that patients transported by helicopter had improved outcomes over those transported by ground. Therefore, many hospitals purchased helicopters and began offering helicopter transport. Today, there are nearly 800 medical helicopters in the United States. In metropolitan Phoenix, Arizona, alone there are more medical helicopters than can be found in all of Canada.

One of the reasons for this proliferation is a change in health care regulations. In the late 1990s, the air ambulance industry was successful in pushing federal regulators to increase Medicare payments for air transports. With an improved reimbursement scheme, an opportunity suddenly opened up for commercial operators to enter the arena.

Many helicopter transport companies opted for less expensive, pre-owned, single-engine aircraft—scores of which had already put in decades of work ferrying oil rig workers to platforms in the Gulf of Mexico. Many of the commercial operators also kept salaries for pilots and medical personnel relatively low in order to field additional aircraft. Medical helicopters became commonplace.

Recently, researchers have again studied the helicopter transport of ill or injured patients and have drawn considerably different conclusions from those of the researchers working two decades earlier. There is increasing evidence that only a fraction of the patients transported by helicopter derive any significant benefit over patients transported on the ground, a change likely due to improved capabilities of land ambulances.

A 2002 Stanford University study evaluated 947 patients delivered consecutively to a California trauma center by medical helicopter and found that only 1.8 percent needed immediate surgery for life-threatening problems. The researchers concluded that only nine of the 947 patients possibly benefited from helicopter transport and that for five patients, helicopter transport was possibly harmful.

Last year, a group of university researchers, including myself, and state officials from Vermont and Wisconsin conducted a study of 37,350 trauma patients transported by helicopter from the accident scene to a hospital. We found that approximately two-thirds of the patients had injuries that, based on validated trauma criteria, are considered minor. (The abstract was published in the journal *Prehospital Emergency Care*, and the full article will soon be published in the *Journal of Trauma*.)

More research may be needed to demonstrate the scope of the problem, but questions about the utility of medical helicopters extend to the highest levels of the medical community. "There is simply not enough science [measuring the utility of medical helicopter transport]," says Richard H. Carmona, U.S. surgeon general and former medical director of the Arizona State Police medical helicopter program. "I am concerned that resources, such as medical helicopters, are used appropriately and cost-effectively for the benefit of the patient." Carmona suggests that air am-

# e n t a r y

## Bledsoe M.D.

DAVID POVILAITIS

bulances be incorporated into the emergency medical system and be dispatched using a common communications system and be held to standards that decrease expenses.

Right now, the air ambulances have a lot of influence over when and where they fly. Overworked hospital physicians will gladly authorize helicopter transport—just to get a patient out of the hospital so another patient can fill the bed. Cost is often forgotten or not considered.

Likewise, at accident scenes, helicopters are easy to call for. Helicopter operations often provide volunteer fire departments and ambulance squads with free pizzas, coffee cups, key chains, and even medical equipment, and encourage the rescue workers to call for the helicopter before they arrive at the scene—long before they have a chance to even lay eyes on their patients. This adds to a system already out of control.

Many families are now being left with air ambulance bills ranging from $8,000 to, as in one case in Arizona, $40,000. Patients are being billed because Medicare administrators and private insurance carriers are more carefully scrutinizing compensation for helicopter transport, possibly because the number of flights paid for by Medicare alone was 58 percent higher in 2004 than the number paid for in 2001. Many of the for-profit helicopter operators hire collection agencies to aggressively pursue patients for payments of these unexpected bills.

Besides cost, safety is a consideration. The proliferation of medical helicopters has been accompanied by a marked increase in the number of accidents, prompting the NTSB to issue a safety advisory for medical helicopter operators last January. The bulletin recommended that ambulance operators improve qualifications of dispatchers, enhance preflight risk assessment, use night-vision imaging, and install terrain awareness and warning systems in all medical aircraft. The air medical industry is slowly beginning to initiate measures to enhance safety and clearly wants to dissociate from the idea that operators are the sole source and solution to the problem.

"Air medical providers are taking the NTSB recommendations seriously," says Edward Eroe, president of the Association of Air Medical Services. "We want to partner with them to improve safety, as we all have to work together to make real improvement."

But the increase in the number of medical helicopters has also resulted in a marked decrease in the number of qualified pilots, flight nurses, and paramedics available for hire. The rise in demand, accompanied by the retirement of Vietnam-era pilots from the medical helicopter ranks, has caused many medical helicopter operators to drop the minimum number of flight hours they require of pilot applicants. Furthermore, because flights equal revenue, some pilots are being pushed to fly in questionable conditions.

The tremendous increase in the medical helicopter accident rate prompted Johns Hopkins School of Public Health researchers to evaluate emergency medical service helicopter crashes from 1983 through April 2005. They found that being a member of a medical flight crew is now among the most dangerous occupations in the United States—six times more dangerous than standard occupations and twice as dangerous as mining and farming—similar in riskiness to the duties of combat pilots in wartime.

Here in the land of plenty, we have created a system that has taken a useful tool—the medical helicopter—and transformed it into the most dangerous and most expensive transport modality available.

**Bryan Bledsoe is an emergency physician, textbook author, and Adjunct Professor of Emergency Medicine at the George Washington University Medical Center in Washington, D.C.**

# GLENN CURTISS SLEPT

## BUT TO VISIT HAMMONDSPORT, YOU MIGHT NOT KNOW IT.

BY PHIL SCOTT

**Local boosters complain that Hammondsport, New York (right), has not properly honored native son Glenn Curtiss, the Wright brothers' primary competitor.**



NASM (SI NEG. #98-15036)

# HERE

THE AUTUMN SUN HAS SET. Paul Geisz Sr. and I have spent about 20 minutes trekking through the thick brush along the south shore of Keuka Lake, in upstate New York. Behind us, bulldozers sit silently after another day of work demolishing the old Garrett Warehouse in preparation for 26 new lakefront condos. Nothing looks particularly historic here; there's no sign telling visitors that on March 12, 1908, on the frozen surface of this lake, the *Red Wing*, the first U.S. airplane designed and built by someone other than the Wright brothers, took off on its first flight.


Wetlands block our way ahead, so we double back to my rental car and head south. We turn into the Hammondsport Junior-Senior High School parking lot. Now we're surrounded by parkland; about 100 feet from us is the lake. By this time it's dark, and the rising moon flickers on the surface of the water. Here, at least, there are a few signs of resident Glenn Curtiss' accomplishments. You can make out an airplane mounted on a pole several feet from shore. It is a model of the Curtiss A-1, the U.S. Navy's first airplane. Next to Geisz and me is a short flagpole in a black, angular stone base about four feet tall. Carved in it are Curtiss' major accomplishments, along with the dedication date: July 4, 1978, exactly 70 years after Curtiss flew the third airplane he designed, the *June Bug*, and won a *Scientific American* trophy for making the first public flight of at least one kilometer. The base also notes Curtiss' 1906 speed record on a motorcycle (136 mph), his invention of the floatplane, and more.


GLENN H. CURTISS MUSEUM (2)

**Before turning to airplane design, Curtiss sold bicycles (top). Though the hotel (above) is gone now, the town's B&H Railroad station still stands.**

"It's not much of a monument," says Geisz, a former cop from Philadelphia in his late 60s who moved here after he retired.

"Well, the Wright brothers were first," I reply. At the spot where they made their 1903 flight, atop Kill Devil Hill in Kitty Hawk, North Carolina, there is a


DEAN CRONK

**Charmed by Hammondsport, Paul Geisz moved there after retiring and bought the Village Tavern. He and Marcia States (opposite) are among the residents who want to see the village create a park to honor Curtiss.**

grand 60-foot-tall Art Deco monument, paid for by the U.S. government.

"He flew a kilometer," Geisz says—almost 3,300 feet. "They flew yards."

"But they did it five years before he did."

"The one who really flew first was Langley. Did you ever see his airplane?"

"Not up close."

"The shot of him flying."

"Where?"

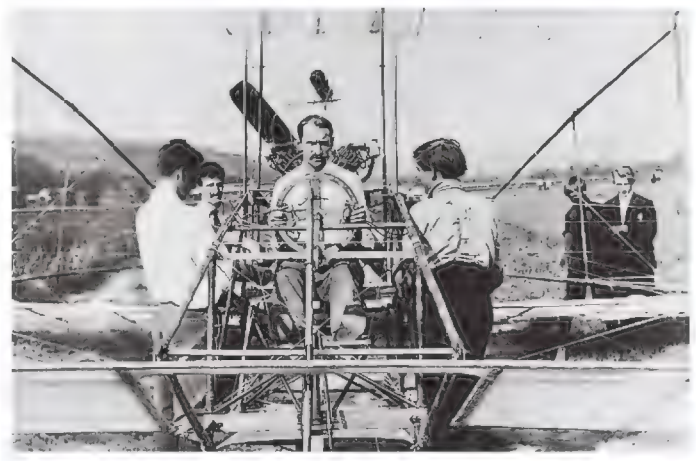
"Into the Potomac," he says.

"Oh yeah, I've seen that one." It dates back to 1903, just before the Wrights' first flight. Smithsonian Secretary Samuel Langley's *Aerodrome* arcs off its houseboat catapult and goes right into the river. That's not flying; it's more like plunging. But never mind.

There's no use arguing about it. The Curtiss people always think they're right. I'm a Wright Guy.

KEUKA LAKE LIES ON the edge of Hammondsport, New York, the quiet village where in 1878 Glenn Hammond Curtiss was born. (Though he was not a descendant, he was named after village founder Lazarus Hammond.) Curtiss was raised here and in Rochester, and it was in Hammondsport that he built and rode motorcycles, designed and constructed early airplanes, and now lies buried alongside his wife and sons. But unlike Kitty Hawk or Dayton, Ohio, where images of the Wright brothers are everywhere, little in Hammondsport indicates Curtiss' presence. At the Glenn Curtiss Museum, which is located outside of town, executive director Trafford Doherty says: "Hammondsport could have done a little more for the favorite son. Not even a statue" pays homage to Curtiss in the village. The grade school bears his name, but it's nowhere on or near the building. The city's phone directories are mostly filled with listings for all the wineries in the valley. This is New York wine country. That's what brings tourists to Hammondsport every summer. Not Glenn Curtiss.

Now a group wants to change that. For starters, Curtiss supporters hope to fly the museum's replica of the *June Bug* in 2008, on the 100th anniversary of that flight. But beyond that, the group, the Friends of Hammondsport, wants to build an 11-acre Glenn H. Curtiss Memorial Park along the southern shore of Keuka Lake. They envision erecting a wrought-iron gate at the entrance, as well as a wall with the names of Curtiss, his family, and the people who worked with him and flew his machines in those early days of aviation. Something substantial. After all, the lake is where Curtiss and his team made history.



COURTESY GLENN H. CURTISS MUSEUM

DEAN CRONK

Carl Slater, an 82-year-old Hammondsport native, says his father (born in 1894) would ride his bicycle down to watch men tinker with an early airplane. "Curtiss needed a part from his shop," Slater says, "and he had no transportation, so he asked Dad if he could borrow his bicycle. He borrowed it and rode it up there. Here is a master of all transportation, and he has to borrow a bicycle from a local kid. Curtiss asked Dad if he liked to swim and Dad says 'Yes,' and he said 'You can come down to the dock anytime you want to,' and my dad took him up on it."

The 11 acres the Friends want to transform is owned by the H&B Railroad, which was built around the turn of the last century to transport wine grapes from Hammondsport to Bath, a small town seven miles south. An abandoned train depot sits on the land, as does a garbage dump.

The railroad wants to sell the acreage; it is required to offer it to the village first. It's asking $1.35 million. So far the Friends have raised 10 percent of that ($5,000 came from the surprisingly still-extant Curtiss-Wright Corporation, which now manufactures stuff like nuclear power plant valves—it's gotten out of the aircraft and engine business). The Friends have until July 31 to raise the other $1.2 million.

HAMMONDSPORT'S Village Tavern, the proverbial clean well-lighted place, sits just north of the town square. On the walls hang pictures of Curtiss, protégé Blanche Scott, and lots of Curtiss aircraft imagery. A pusher propeller, on loan from the museum, is on one wall, while from the ceiling hang models of Curtiss airplanes. Paul Geisz, the ex-cop, is the tavern's most recent owner.

Before the lunch rush, Geoffrey Grimsman sits just inside the door at a round table. A motion picture set designer who has a vacation home in Hammondsport, Grimsman is blond with intense blue eyes. As we drink coffee, he brings up a recent visit to Gettysburg, Pennsylvania. He says the Friends' park fight is a lot like that. Not like the battle itself, but the more recent dispute between those who want to leave the battlefield as it has been preserved, and those who want to surround it with strip malls and hotels.

DEAN CRONK

**In the *June Bug* (opposite, inset), Curtiss makes the first flight of at least one kilometer (below). The barn in the background of that iconic image survives today (opposite, bottom).**

The Friends recently tried to raise the money through a referendum, which was voted on in July 2004. "The cost per taxpayer would amount to a 12-pack of Pepsi or Coke a month," he says.

"For how long?" I ask.

"Twenty years," he replies.

That's a lot of soda.

A little more than 800 voters cast ballots, and the measure was defeated by 43 votes. The same people voted funds for a new library. ("In the age of the Internet?" Grimsman asks.) "A park would


COURTESY GLENN H. CURTISS MUSEUM

be somewhat instrumental in leveling the historical playing field," he says. Curtiss' contributions to making the airplane practical—the seaplanes, the engines, the formation of the Aerial Experiment Association with Alexander Graham Bell, the World War I Jenny JN-4 trainer—all have been eclipsed by the accomplishments of the Wrights, say supporters.

Grimsman notes that Curtiss was more open with his inventions than his competitors were: "The Wrights said, 'Let's see if it works and then we'll tell everybody.' Curtiss said, 'Let's tell everybody and see if it works.' "

COURTESY GLENN H. CURTISS MUSEUM

**Curtiss (at left, next to his Model F flying boat) entertains visiting auto magnate Henry Ford around 1914. Ford provided legal aid to Curtiss when he was sued by the Wrights for patent infringement. Right: Town supervisor Dick Gardiner, in one of the rooms of the old village school, which Curtiss attended.**

Now, the way I see it, the Wrights weren't that secretive. They recruited a few local lifeguards to witness the 1903 first flights. And the brothers did not object when sightseers would watch them fly at Huffman Prairie in Dayton in the early years of their experimentation. Once they even invited members of the press to come out and witness a few launches. The first published account of the Wrights making a powered flight appeared in 1905, three years before the brothers' first official flight. But as I said, I'm a Wright guy.

Later that day, I meet another one of the Friends, Marcia States, who's short and sturdy and blonde. She picks me up at the tavern in her dilapidated 1993 Ford Escort station wagon, which is filled with campaign signs (she's running for county legislator; I find out later that she lost) and drives me north. She turns right by the remaining pillars of the Garrett Warehouse, then right again, and parks in front of the village hall. It's an old building, but not a charming one. It was once a school and looks like it. Curtiss himself used to attend classes here. There's no sign saying that, of course. But later Carl Slater tells me that his father went to school there too, maybe a decade after Curtiss. "Once, as he walked down the street, he saw three men coming the other direction: Curtiss he knew by sight; the other was Alexander Graham Bell, and then Henry Ford."

Today the ancient classrooms contain mostly village government offices. One houses the soon-to-move library, which is packed to the rafters with books.

I get to talking with Town Supervisor Richard Gardiner, a retired math teacher with thinning gray hair and glasses who is wearing a white short-sleeve shirt and tie. I ask why the Glenn Curtiss Museum had moved out. "The building's too restricted in space," he explains. "They couldn't display the airplanes with their wings on."

Today the museum is located half a mile south of Hammondsport. It has a 1912 Curtiss pusher, a 1917 Jenny, and two flying boats: a 1913 Model E and a 1919 Seagull. It also owns a handful of aircraft from the Curtiss-Wright company. Director Trafford Doherty says the museum is not involved in the Friends' efforts. "We had Marcia States in the museum for the first time about five, six weeks ago," he says. "We had a nice talk; she's very interested in local history. None of the other [Friends] have been here. They're interested in their park."

Gardiner and I turn to the failed park referendum.

"My hope is that people will re-vote it," Gardiner says. "I believe this time it will pass. They'll see the [Garrett Warehouse] coming down at the lake and so now they've seen a part of the lake they've never seen before." The warehouse had blocked the view since the second decade of the last century.


CAROLINE SHEEN (2)

**Marcel Rouin, here at the Curtiss family grave site, has childhood memories of the inventor.**

**Michael Doyle, owner of the Pleasant Valley Wine Company, owns the lakeside property that the Friends of Hammondsport hope the village will buy for a memorial park.**

States and I get back in her car and head for the exact place where Curtiss flew the *June Bug* that day in 1908. Along the way she drives through an area that once held the Curtiss factory, a building that evokes the fondest memories for the people who were alive back then.

"I never met, never saw Curtiss," says George Winters, 89, who now lives in nearby Bath, where he worked during World War II building aircraft parts for machinist Henry Kleckler. "He practically worshiped Glenn Curtiss," says Winters. Really, Winters shouts it, because he's nearly deaf. "Kleckler worked for Curtiss before World War I. He was the man who designed the OX-5 engine [which powered the Curtiss Jenny]. Curtiss went broke and he had to lay off his help. Kleckler was more interested in the work part than the pay part, so he kept on working and Curtiss kept on giving him his worthless stock. But the war came along and Curtiss got a big contract and the stock became very valuable. Kleckler, he made a lot of money from that 'worthless' stock."

Near where the factory once stood, now a parking lot and playground, is the site of Curtiss' home. The house burned down in the 1960s, but 84-year-old Marcel Rouin Jr. remembers it well. "I saw him when I was nine years old," he recalls. "There was a tree right next to his house where he used to live. He was very famous then. A bunch of his friends were in the house; we were up in this tree eating cherries. He came out with about four of these men and watched us eat. Didn't bother them a bit."

DEAN CRONK

States and I arrive at the gates of what was once the Mercury Aircraft Company; now it's a company that makes computer covers, doors, frames, and no aircraft whatsoever. We can't get too close because we're on private property, States explains. So we remain inside the idling station wagon, ready to burn rubber if someone sees us, while she points out items of interest.

"That's the barn you see in the background of the photograph," States says, nodding to the red barn up ahead, which appears in a classic image of aviation history: the *June Bug* making the trophy-winning one-kilometer flight.

At the foot of Kill Devil Hill, builders used the Wrights' pictures as references to erect a replica of the brothers' camp as it stood in 1903: the shack they slept in, the *Flyer*'s hangar, and the wooden rail they used for launching. Here, by contrast, only grass sprouts from the now-plowed-under racetrack from

CAROLINE SHEEN

**Standing in front of the real thing, director Trafford Doherty admires a Jenny model at the Curtiss museum.**

which Curtiss took off. There used to be a New York State Historical Marker nearby, but it went missing a short time back. Under a shade tree sits a wooden picnic table with flaking paint.

The barn is also visible from Michael Doyle's office in the Pleasant Valley Wine Company. Doyle, tall with dark brown hair, is the winery's president, and he also owns the 26 condominiums being built on the banks of Keuka Lake, and the H&B Railroad, which means he is the one who owns the 11 acres of land that the Friends of Hammondsport want to buy. Doyle is unmoved by the Friends' campaign. "The hill across from the museum is owned by the town," he says. "It's 180 acres, part of the original farm sold to the museum. They could name that for Glenn Curtiss." (Later, I ask Marcia States about this suggestion; she says that this piece of land already has the town barn and a bus garage, plus "it's not easily accessible.... There's a road but it's very difficult to get to. It's land that is not usable for a park.")

Doyle continues: "There are so many parks around for the 2,400 souls who live in the town of Urbana [to which the village of Hammondsport belongs], I don't think we need any more." Doyle says he wants to hold on to the land, maybe build a new railroad


COURTESY GLENN H. CURTISS MUSEUM

NASM (SI NEG. #A-28872)

**Above: Curtiss' flying boat operations at Keuka Lake in 1913. Right: The following year, Curtiss (at right) and team ready Samuel Langley's controversial *Aerodrome* for flight at the lake.**

of some kind. "Just to kind of keep it in play," he says. "I'd like to re-create some kind of passenger service on it."

Geoffrey Grimsman has a different vision. "Perhaps we can let another person stand on the bank and stare out at the lake and dream of great things," he says.

States and I drive to Pleasant Valley Cemetery and get out to pay our respects at the shady Curtiss grave site. There is a large family stone bearing the name "Curtiss," but the inventor's headstone is of modest size. Very few folks in Hammondsport have any memories of the day Curtiss was buried, 76 years ago. "I was six years old in '30," says Carl Slater, "and my brothers knew that Curtiss had died. They assumed he was going to be buried in Hammondsport Cemetery. We started out walking to the hill to watch the funeral and when got there we found out that he was to be buried in Pleasant Valley."

It was not long after the cherry-tree incident, but Marcel Rouin can just barely remember the burial. "I remember seeing things dropped from airplanes," he struggles to recall. "Maybe it was Lindbergh or somebody else, a message or something. I can't remember what the day was like—I think it was in the spring or summer." It was late July. Ten airplanes circled the cemetery, and each swooped down and dropped flowers.

States drives us back into Hammondsport, past the unmarked house in which Curtiss was born and where he lay in state after his death following an appendectomy, at the age of 52. A later owner screened in the porch and painted the place dark brown.

I ask States if she thinks the Friends of Hammondsport will ultimately prevail, and will manage to raise the additional $1.2 million needed in the time they have left.

"I hope so," she says, and pauses. "My grandmother called him 'Our Glenn Curtiss.' She loved him. Couldn't stand his motorcycle though." She lets out a breath. "I rue the day this all gets developed."

NASM (SI NEG. #00156158)


DEAN CRONK

**Above: The 1912 Model F flying boat, which Curtiss sold to the U.S. Army. Below: Near a ferry landing stands one of Hammondsport's few memorials to Curtiss (in the distance is a model of his A-1, the U.S. Navy's first airplane).**

# FLOAT

**Mars, Venus, Titan – wherever there's air, we can explore by balloon.** by Joe Pappalardo

# TERS

At a quiet airstrip near Tillamook, Oregon, 10 people in comfortable running shoes take their positions along an 82-foot tether secured to the front of an SUV. At the far end of the line, a giant helium balloon bobs like a translucent white jellyfish. As they stand holding the connected components of an instrument payload attached to the tether, some of the runners wait for a signal from Jet Propulsion Laboratory engineer Jack Jones, who's standing by the SUV, hand on the release mechanism, peering at the teardrop-shaped balloon. For this test, being conducted in December 2005, the payload is bound for the stratosphere. But Jones' interests range much farther. Inside one of the payload canisters is another, smaller balloon similar to the ones he'd someday like to fly over Mars.

At around noon, Jones releases the helium tow balloon and the scramble begins. To ensure a smooth sendoff, the members of the ground crew have to stay under the drifting balloon. That means running, components in arms, and letting go only when they're directly underneath it. One by one, the pieces take flight: a parachute, the stowed Martian balloon—a Montgolfiere hot-air type, named for the French brothers who pioneered the technology in 1782—and a sensor package with guidance system, radio transmitter, and video camera. At an altitude of 22 miles, where the thin air resembles the Martian atmosphere, the scale-model Martian balloon is supposed to separate with its own parachute, cut away from the parachute, inflate, and float to the ground. But with-

**JPL's Jack Jones was among the early converts to planetary balloons. Here he holds a sample collector that may someday drop from a balloon to the surface of Saturn's moon Titan (opposite).**

OPPOSITE: NASA; LEFT: CHAD SLATTERY

in a minute or so of initial separation it gets tangled in the parachute, and after a couple stressful minutes, it tears apart.

Later, Jones, usually gregarious and prone to bouts of rumbling laughter, makes a wounded-animal noise as he recalls the scene: "When you drop five kilograms of payload 30 meters [from the tow balloon], it's a big tug on the balloon. It's kind of like popping a paper bag." Looking on the bright side, this was the largest hot-air balloon ever to survive its deployment in the stratosphere. So in strict engineering terms, it hasn't been a total disaster, and another test is planned for this year. But setbacks like this have already cost Jones and his fellow balloonists the chance to be considered for NASA's 2012 Mars Scout mission, a new, economy class of Martian expeditions using small landers or aerial vehicles.

Luckily, the solar system is big and other places beckon. The team is also designing a balloon mission for Venus, which they have submitted to NASA's slightly pricier Discovery program. And the aerostat office at JPL is hard at work on concepts for a balloon mission to Saturn's moon Titan.

The idea of balloons flying low and slow over alien landscapes appeals to researchers like Wolfgang Fink, a physicist and visiting associate at the California Institute of Technology who co-authored a report last year in the journal *Planetary and Space Science* arguing for a mix of techniques for exploring other worlds. "We're not trying to take anything away from the successful landings on Mars, Venus, and Titan, nor the orbital-based successes," Fink says. "We're looking at a new way to cover lots of distance."

Planetary balloons can travel farther than rovers and get closer to the surface than orbiters, sniffing the atmosphere or taking pictures and temperature readings as they go. For JPL's engineers, their value as research tools has always been obvious. The technology, not the rationale behind it, is what needs shoring up.

## How Do You Control This Thing?

JPL AEROBOT ENGINEER JEFF HALL admits it: "A lot of scientists don't like balloons because you can't steer them." But Alexey Pankine, a project scientist with the Global Aerospace Corporation in nearby Altadena, California, thinks he's found a way around the problem. With funding from NASA's Institute for Advanced Concepts, he has come up with concepts for steerable balloons that could work in the atmospheres of Venus and Titan, and even the thin air on Mars.

Taking advantage of the natural differences in wind speed at different altitudes, his system dangles a single- or double-wing assembly below the balloon, about nine miles down in the case of Mars. The wind at the balloon's altitude will usually be faster than it is near the wing, so the steering assembly will tend to pull back on the balloon. The wing looks like a glider turned on its side, so its "lift" is lateral rather than upward. A rudder about half the size of the wing pulls it to one side or another, and because the wing tugs on the tether, the balloon is dragged in that direction.

"This force is applied constantly," Pankine says. "We're not expending any energy—it's completely passive."

A solar- or battery-powered electronics module in the wing assembly would power the rudder, and researchers on Earth would be able to steer the airship, though not very precisely, by radio control. Carrying a 220-pound science package, it could stay aloft for 700 days. Hall is enthusiastic about Pankine's ideas. "I think it's great stuff," he says. "The problem is weight. His balloons would have to be very large." Still, JPL's aerostat team would love to reach a point where that's their only worry.

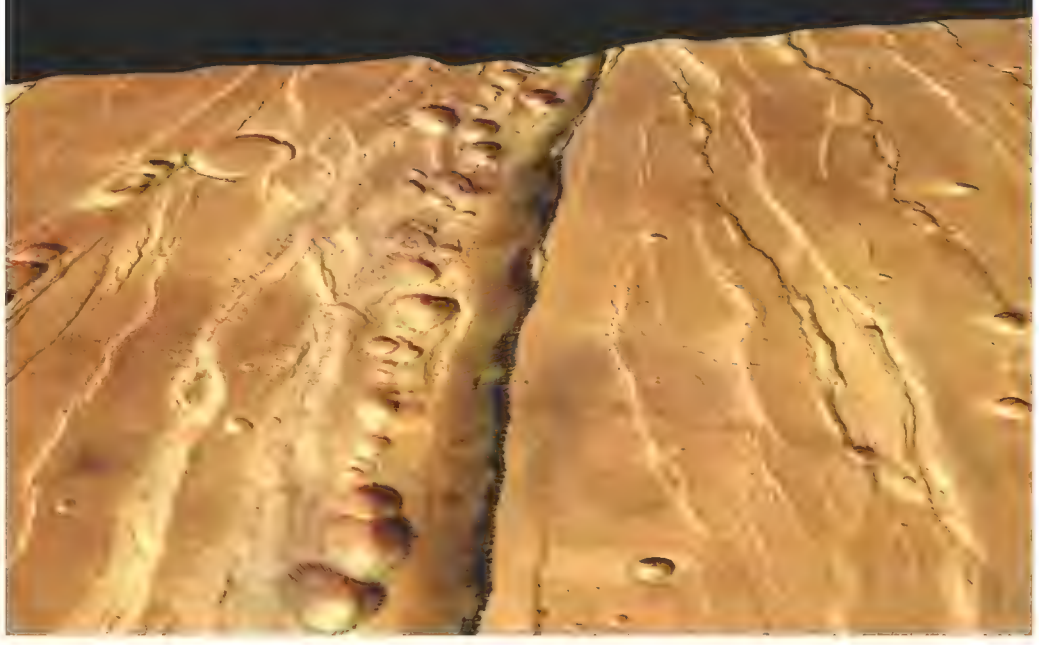


PHOTO: ESA/CLUSTER

IN 1995, WHILE ATTENDING a conference in Japan, Jim Cutts made a side trip. As JPL's advanced projects manager, he jumped at the chance to go to Osaka to observe the manufacture of a new material, Zylon, one of the strongest synthetic fibers in the world. Used for bulletproof vests, its high tensile strength and heat resistance made it perfect for balloons that have to survive the harsh conditions on Venus.

At the time of Cutts' trip, interest in planetary balloons was at an ebb. The Russian Vega probes that visited Venus in 1985 had carried French-designed helium balloons that spent two days studying the atmosphere as they floated. But it was downhill from there. Another French-Russian aerostat, this one for Mars, was delayed twice for money problems, then removed from a 1996 Mars-bound probe, which end-

**Spectacular photos of the Martian surface, like this one, returned in 2004 by the High Resolution Stereo Camera on board the European Mars Express spacecraft, can be taken from orbit. For microscopic close-ups, rovers on the ground can press up against rocks. Where balloons would shine is in the middle range—they could get closer than orbiters, and cover more territory than rovers. Still, the thin Martian atmosphere presents a challenge to balloonists. On the Red Planet, airplanes may be the way to go.**

CHAD SLATTERY

ed up crashing to Earth shortly after launch anyway.

By then the United States had already picked up the torch. In 1993, JPL researchers including Cutts, who today serves as the lab's Chief Technologist for the Solar System Exploration Directorate, and Jack Jones had scanned the list of planets and moons with atmospheres and begun working on designs for balloons to use for Venus, Mars, and Titan. By 1997 the lab had a Mars Balloon Validation program, which aimed to prove that aerial inflation of a balloon over Mars was possible. It would take more than just filling a sphere with gas and setting it adrift. The whole EDI—entry-descent-inflation—sequence had to be carefully worked out, from high-speed entry into the Martian atmosphere to separation from the incoming spacecraft to the timing and method of inflation.

"On some level, balloons are very simple devices," says Jeff Hall, JPL's lead engineer for interplanetary lighter-than-air missions. "On other planets, with different environments, it gets difficult quickly."

In 1997 and 1998, the JPL engineers conducted dozens of low-altitude deployment tests of small (up to 17 feet in diameter) hot-air Montgolfiere balloons launched from Oregon. All the tests were successful. Three of the flights even demonstrated an altitude control system that used a radio-controlled gas vent in the top of the balloon to control its rising and falling. The idea was to show that Montgolfiere balloons could be safely navigated to within about 100 yards of a planetary surface, which is close enough to drop a sample collector to the ground.

From 1998 to 2002, the balloonists turned to high-altitude tests that better simulated deployment in the thin, cold Martian atmosphere. Some of the Mylar balloons used for these tests ended up ripping.

**"ON SOME LEVEL BALLOONS ARE VERY SIMPLE DEVICES. ON OTHER PLANETS, WITH DIFFERENT ENVIRONMENTS, IT GETS DIFFICULT QUICKLY."**

**–JEFF HALL, JPL'S LEAD ENGINEER FOR INTERPLANETARY LIGHTER-THAN-AIR MISSIONS**

But three of four small (up to 50 feet in diameter) polyethylene balloons deployed successfully in the stratosphere. When larger polyethylene balloons were tried, they failed shortly after deployment. Realizing that the larger balloons experienced greater stress during deployment, the engineers tried stronger balloons with a gentler deployment sequence.

That appears to have done the trick. Jones' most recent flight from Oregon, made in December, resulted in a successful deployment of a 66-foot Montgolfiere lasting one minute, until its parachute descended and collided with the slower-descending balloon. An 83-foot Montgolfiere is scheduled to be flown this summer, and this time it will be equipped with a gliding parachute to prevent the same outcome.

Armed with at least partial success, in 2002 Hall and Jones submitted competing proposals to NASA's Mars Scout program, which, beginning with next year's Phoenix lander, will send small missions focused on a few scientific objectives to the Red Planet at regular intervals. True to their preferences, Hall submitted a design for a balloon inflated by helium tanks, while Jones proposed a Montgolfiere balloon that fills with heated Martian air as it descends. This time they competed, but just as often they collabo-

JPL/NASA

**Testing a scale model of the Titan aerobot in the Mojave desert. Since 2001, JPL engineers have flown their invention more than 20 times.**

rate. NASA's planetary balloon program is not large enough for civil war.

Nor is Mars the best place to demonstrate a balloon's advantages. Because the atmosphere is thin, the designs most likely to succeed are large, thin-skinned balloons carrying small payloads. The payload falls faster in thin air, so deployment and inflation are quick and violent. That puts the balloon under a lot of stress, increasing the risk of a tear or a tangle. Still, because opportunities to fly in space are rare, when NASA first solicited ideas for Mars Scout missions in 2002, the aerostat program threw the two contenders into the ring.

**THE HUYGENS PROBE'S BRIEF LOOK AT SATURN'S MYSTERIOUS MOON TITAN WHETTED SCIENTISTS' APPETITE FOR A MORE THOROUGH INVESTIGATION. AND TITAN'S ATMOSPHERIC PRESSURE – ABOUT 60 PERCENT GREATER THAN EARTH'S – MAKES IT BETTER SUITED THAN MARS FOR EXPLORATION BY LIGHTER-THAN-AIR MACHINES. "WE'RE ONLY UNDERDOGS ON MARS," SAYS HALL.**

Even by NASA standards, the competition was intense. Facing about 30 other proposals, neither balloon mission made the first cut. "The science was excellent but the technology was not yet ready," says Samad Hayati, manager of JPL's Mars Technology Program. The problems of entry and inflation were still unsolved, and NASA wanted a smaller navigation package. In addition, Hall says the proposal included too much detail on past French and Russian balloon projects, a mistake he will not make again. "Saying the Russians did it first does not carry a lot of weight at NASA," he deadpans.

The balloons also faced competition from a Mars airplane with similar scientific goals, called ARES. Says Hall: "Airplanes and balloons are close to direct competitors," since they both fill the niche between orbiters and surface rovers. ARES survived to the final round of proposals, only to lose to the more conventional Phoenix Mars Lander, which will go on the first Scout launch next year. The airplane's good showing led to additional funding and a higher profile that improves its chances for this year's competition. In contrast, no balloons are likely to be proposed for the 2012 Mars Scout opportunity. Hayati says that if the complexities of entry, deployment, and inflation can be solved for the thin Martian atmosphere, things might change. But for now, the aerostat teams are turning their attention to other worlds. Atmosphere required.

THE SCATTERED BUILDINGS OF the Jet Propulsion Laboratory stand against the San Gabriel Mountains outside Pasadena like a college campus tossed carelessly onto a hillside. New employees live and die by facility maps. After a while they learn to ignore the deer that routinely graze on the sculpted lawns. Harder to ignore are the occasional mountain lion tracks found outside the buildings or between cars in the parking lots.

Jeff Hall's aerostat office is tucked away in a nondescript building that at first blush resembles a trailer. Entering the lab doesn't dispel the impression—it looks like nothing more than a plain rectangular meeting room. But step through a side door and you find the heart of the place, a 1,500-square-foot workshop. Winches, workbenches, soldering equipment, and rolls of balloon material indicate the kind of hands-on work being done here. In one corner, past the sensor payloads and video processing equipment, an undergraduate student attaches straps to a rolled-up trial balloon.

Then there's the fully inflated, 36-foot-long blimp, lashed to a 60-foot table.

This, Hall explains, is the test bed for an aerobot designed to explore Saturn's largest moon, Titan. The Huygens probe's brief look at the cloud-covered moon last year (see "219 Minutes on Titan," Oct./Nov. 2005) whetted scientists' appetite for a more thorough investigation. And Titan's atmospheric density—about four to five times greater than Earth's—makes it better suited than Mars for exploration by lighter-than-air machines. "We're only underdogs on Mars," Hall says.

The test bed is slightly smaller than the actual, 50-foot Titan airship would be. Since 2001, it has flown nearly 20 times in the Mojave Desert, northeast of Pasadena, operated by a pilot on the ground or by the onboard computer. The main objective has been to test a basic autopilot system and a more sophisticated guidance system that determines the balloon's motion from video pictures of the terrain below.

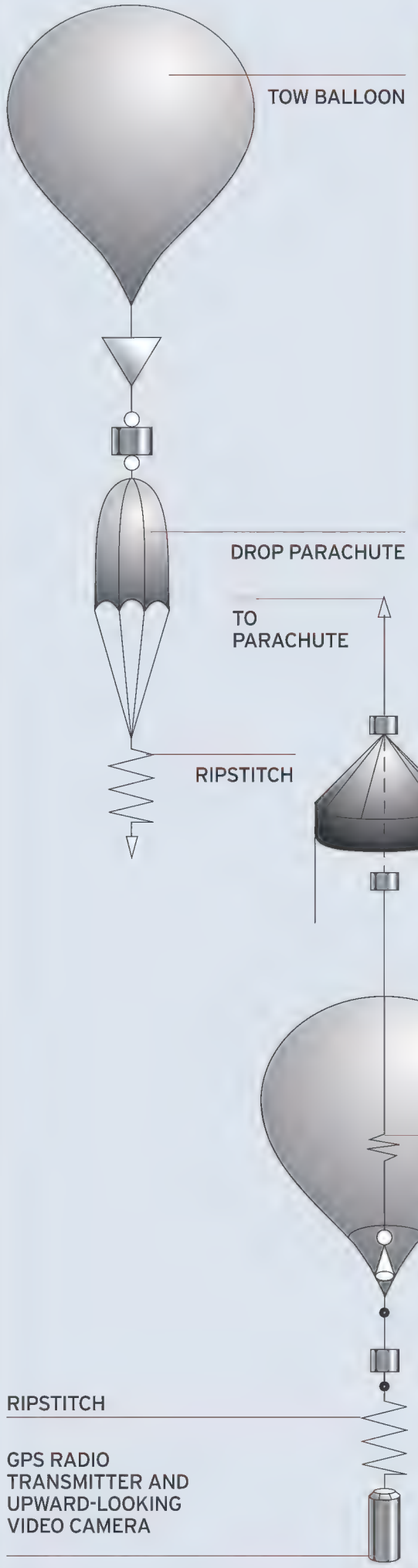
A Titan aerobot will need to be able to react to its surroundings without help from Earth, since radio signals take 70 or 80 minutes to travel one way, and at times Saturn will block direct radio signals altogether. "You just can't joystick it from down here," Hall says.

The prototype has a gasoline engine to fight winds in Earth's atmosphere. The real one would likely have a nuclear power source that could keep the balloon conducting science investigations for as long as six months, and even longer if researchers can slow the rate of gas leakage or replenish the gas.

It also will have to operate in the hostile environment of Titan, where it rains methane and surface temperatures drop to –289 degrees Fahrenheit. Having designed machines for the space environment, Hall knows what happens if you dip a bal-

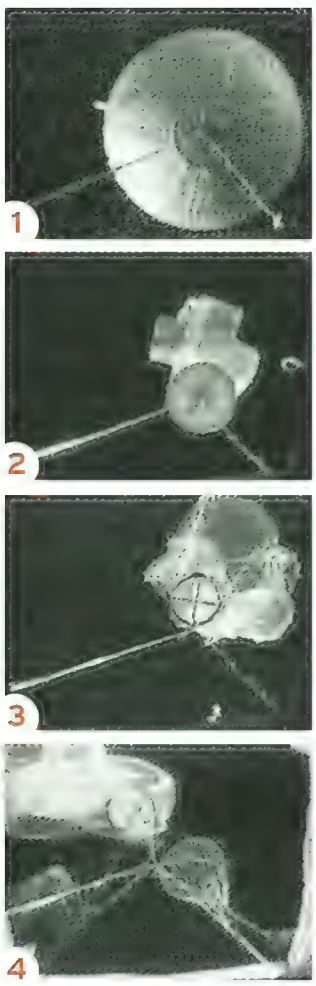
## What's Supposed to Happen

REHEARSING FOR A MARTIAN DEPLOYMENT, the JPL balloonists send their hot-air balloon to the stratosphere under a bigger helium tow balloon. The parachute detaches from the tow balloon. Then the still-bagged Montgolfiere balloon cuts from the chute, inflates, and floats on its own.




**Success! Last year a 66-foot-wide hot-air balloon (crammed inside the sphere under the helium balloon) survived initial deployment in the stratosphere.**

JPL/NASA




JPL/NASA

**High test: At an altitude of 22 miles, a video camera attached to a tether looked up (1) at the helium tow balloon and the about-to-inflate hot-air balloon. After descending on its parachute (2), the hot-air balloon inflated for over a minute (3), but then quickly got tangled (4) in the parachute.**

loon in liquid nitrogen and throw it to the ground: It smashes into pieces. That's something the JPL engineers would like to avoid.

A 2002 small-business solicitation requesting solutions brought a response from the New Jersey-based Lamart Corporation, which usually makes high-performance sail material for America's Cup sailboats. The company offered a blend of their high-performance fiber and Mylar as a possible balloon material that could withstand Titan's deep freeze. For the past three years, the material has been torture-tested in cryogenic conditions and vacuum chambers. "Fabric for toughness and film for gas retention," Hall says, twisting and pulling a sample of the material in both hands.

Along with their blimp-like aerobots, the JPL engineers have been looking lately at conducting a Titan mission with Montgolfiere balloons, which have the advantage of being simpler. In collaboration with the balloon team at Wallops, they have signed another small business to develop an even more esoteric technology: a way to convert the smoggy atmosphere of Saturn's moon to gas for inflating a balloon. Lynntech Inc. of College Station, Texas, normally is involved in fuel cell research. Since Titan's atmosphere is three percent methane ($CH_4$), hydrogen could be extracted from the gas and used to replace gas lost from the balloon. The trick is to make the converter lightweight, low-power, and reliable. JPL and Wallops are currently funding the creation of a full-scale prototype that weighs just 11 pounds and runs on only 10 watts of electrical power.

THE TERM "METAL BALLOON" MIGHT SEEM AN OXYMORON, LIKE "JUMBO SHRIMP." BUT WHEN DESIGNING LIGHTER-THAN-AIR VEHICLES FOR VENUS, UNCONVENTIONAL THINKING IS REQUIRED.

The balloonists have also set their sights on Venus, the closest planet with an atmosphere and the only one where a scientific balloon has already flown. Although spacecraft have skirted past, orbited, and landed on the planet since 1962—the most recent is Europe's Venus Express orbiter, which arrived in April—fundamental questions remain. The thick hazy atmosphere prevents high-resolution photography from orbit, so scientists have to rely on radar images to view the topography. And only a handful of photos of the surface exist, taken by short-lived Soviet landers in 1975 and 1982.

Scientists also want to bring Venusian rocks back to Earth, but launching a sample container directly from the surface, through the dense atmosphere, and into orbit is very tough. Balloons could save the day by lifting the sample-containing rocket to a higher altitude and launching it from there. First, though, a balloon has to be built that can handle the harsh Venusian atmosphere. The upper layers have thick, corrosive clouds, while the bottom layers, close to the surface, are a scorching 450 degrees . "It's really like two atmospheres," Hall explains. "One is Earth-like, except for the clouds of sulfuric acid."

## FIND OUT MORE www.airspacemag.com

**NINETY-EIGHT LUFTBALLONS TO GO** If the Mars Society of Germany is very lucky, NASA might be watching the first-ever Martian flight on cable news. The private group wants to hitch a ride on hardware from the Radio Amateur Satellite Corp. to sail a balloon over Mars. Backed by supporters in industry and at a handful of the country's technical universities, the group calls its mission Archimedes, and you can read more about it at **www.airspacemag.com.**

CHAD SLATTERY

JPL/NASA

**Left: Balloon guru Jim Cutts shows off the tough, heat-resistant material from which Zylon fiber is made. Above: In the smoggy atmosphere of Titan, cold, rather than heat, will be the problem to overcome.**

Finding a single balloon material that can withstand both of these environments has proven difficult. Materials like Zylon can handle the heat. But at higher altitudes Zylon would be corroded by sulfuric acid. And Teflon, which could survive the acid, is brittle at the high temperatures down below. "Many people have looked at a single balloon [for both atmospheres]," says JPL's Viktor Kerzhanovich, who worked on the Soviet Venus balloon missions before coming to the United States. "As far as I know, none would be successful."

His solution, unveiled at an aerospace conference in Washington, D.C., last year, is a two-balloon system. The first would operate near the planet's surface and would look like a cylindrical bellows made of extremely thin sheets of stainless steel "or other suitable alloy," according to Kerzhanovich's paper. The term "metal balloon" might seem an oxymoron, like "jumbo shrimp," but when designing lighter-than-air vehicles for Venus, unconventional thinking is required.

In fact, a corrugated-metal cylinder leans in one corner of the JPL workshop. The bellows is flexible enough that it can be squished like an accordion for storage on the way to Venus, and tough enough that it could survive the clouds of acid. Filled with helium, the thin metal balloon would rise from the surface of Venus, taking photos or carrying a sample container, depending on the mission. When it got above the hot zone, some 10 miles up, it would release a second balloon, which would climb to higher altitudes.

The metal balloon concept isn't quite ready for prime time. For this year's Discovery mission competition, Hall, Kerzhanovich, and colleagues from JPL and the Universities of California, Michigan, and Wisconsin at Madison submitted a more conservative concept. It uses layers of balloons, one tucked inside the other, and operates only in the upper Venusian atmosphere. An entry vehicle would jettison a folded, 17-foot-diameter balloon, which would inflate under a parachute, detach, and begin floating in Venus' upper atmosphere, protected from the acid clouds by a layer of Teflon film. The balloon would last about a month.

The JPL team finished a prototype of this Venus balloon in February, just in time to make the April deadline for Discovery proposals. If the design is selected this fall, the team will get more money to refine their study. Then, if they get the green light for full funding next year—a long shot, admittedly—their projected launch date to Venus would be the autumn of 2013.

Along with the technical details, a scientific paper by Kerzhanovich's Discovery proposal team includes a stirring vision of what their invention might spawn. "In the not-too-distant future, aerial rovers directly descended from the Venus aerostat could be plying the skies above treacherous landscapes and inhospitable depths of a number of worlds across the Solar System.... Such an aerial vehicle funded on a Discovery-class budget would herald a new era in planetary exploration."

The aerobot researchers are well aware that they've got a lot of hard engineering to do first. And there's always that frustrating Catch-22 of the space business: You can't fly until you're proven, and you can't be proven until you fly. But don't cry for Jack Jones, Jeff Hall, and their crew, whether testing prototype airships in Oregon or over a tabletop in California. They'll tell you themselves: It may not be easy to be a balloonist in a world of rockets and wings, but it sure can be fun.

# BEAUTIFUL CLIMBER

*In the summer of '58, nothing was faster to 50,000 feet.*

BY CARL POSEY

Near dawn on a sparkling spring day, a tailless jet fighter shaped like a manta ray taxied into position on Runway 21 at the Naval Air Missile Test Center at Point Mugu, California. Pointing the airplane into the dense, cold air flowing off the Pacific, Marine Corps Major Edward N. LeFaivre applied full power with the brakes on, then, brakes off, lit the afterburner. The aircraft screamed down the runway for the ten seconds it needed to reach 150 mph and lifted off in a 70-degree climb, tracked by missile-range cameras and radar. Two minutes and 36.05 seconds after releasing the brakes, LeFaivre was at 50,000 feet. It was the fastest time to that altitude in history.

The airplane that set that mark was not a daring experiment in delta-wing technology, but a Navy fighter that had been in development for more than a decade, had served with the fleet for two years, and was already entering the twilight of its service life. Yet as of May 23, 1958, Ed LeFaivre's airplane could still outclimb any other military jet, foreign or domestic.

Douglas designed the aircraft to meet the Navy's 1947 requirement for a land- or carrier-based jet interceptor quick enough to catch and kill an approaching enemy bomber flying at 500 knots (575 mph) and 40,000 feet within a 100-mile radar range. To do this, the jet would have to reach 40,000 feet in five minutes and be able to fight when it got there.

Named the Skyray for the unique shape of its wing, LeFaivre's aircraft was known by those who flew and cared for it as the Ford, from its designation, F4D, and fighter pilots' penchant for understatement. In fact, there was nothing Ford-like about the Skyray. It was exotic and fast, the first of the high-performance designs born during the post-World War II fascination with delta wings, which sprouted on military aircraft around the world like fins on late-1950s automobiles. Many had been inspired by the 1930s experimentation of German aircraft designer Alexander Lippisch. He, in turn, attributed the delta wing to a gift of a zanonia seed, sent him by a colleague during the 1920s. Triangular and airworthy, zanonia seeds can glide a good distance from their parent vine on the weak thermals of the Indonesian rainforest.


EDWARDS HISTORY OFFICE

**Aircraft designer Edward H. Heinemann won the Collier Trophy for the F4D Skyray (opposite), the U.S. Navy's first fighter capable of supersonic speed in level flight.**

The more immediate provenance of the Skyray was a visit to Paris in the week following VE Day, during which Douglas engineers Gene Root and A.M.O. Smith acquired a trove of German wind tunnel data and were able to listen to Lippisch, then in Allied custody, brief his captors on the flying-wing interceptors he believed were aviation's future. Smith and Root returned to El Segundo and the legendary California design-works run by Edward H. Heinemann, where engineers started playing their own supersonic variation on the Lippisch theme.

"The original layout we had at Douglas was very much like Lippisch's plan, which had a sweepback of 45 degrees," recalls Malcolm J. Abzug, a control and stability engineer present at the Skyray's creation. "As I remember, it was okay, but the airplane couldn't be balanced. So the sweepback was increased to 52.5 degrees." Increasing the degree of sweep balanced the aircraft by shifting the wing's area in relation to its center of gravity, the point around which the aircraft pivots in pitch. "All this was under A.M.O. Smith," Abzug says. "His first name was Apollo, so he went by initials; we called him Amo Smith."

OPPOSITE: NASM (SI NEG. #A-4113-H)

The first design was a wing that could easily have flown off the drawing board of Lippisch himself. Then, like a reptile morphing into a bird, the new fighter began to take shape: A rudimentary fuselage appeared, and the wings shrank to a smaller triangle.

One of the youngest members of the design team was Erven Heald, who had come to Douglas in 1940, fresh from the University of Michigan. "Heinemann would just come up with a design and take it to one of the engineers to be turned into an airplane," he says. "When he showed me the Skyray he asked if we could make one, and I said yes, but the center-of-gravity travel can't be more than about five percent." That limited what could be hung on the airplane, and where. "My role was just the flying qualities, how to make it stable and controllable." With a grin, he adds, "Stable and controllable was a challenge."

NATIONAL MUSEUM OF NAVAL AVIATION


NAVAL HISTORICAL CENTER/NAVAL AVIATION NEWS

**Fords of the Navy's VFAW-3 wing wore a glamorous paint scheme. The first Marine squadron to fly the aircraft, VMF(AW)-115 (right), deployed from North Carolina.**

The first design could have flown off the drawing board of Lippisch himself. Then, like a reptile morphing into a bird, the new fighter began to take shape. A rudimentary fuselage appeared, and the wings shrank to a smaller triangle.

In October 1950, not quite a year after the Navy awarded a contract to build two prototype Skyrays, Douglas rolled out the XF4D. It was neither a flying wing nor a delta-wing airplane, but something in between. To those who would come to love the craft, its planform looked like a valentine. To others it looked like the ace of spades.

Because the Skyray had no horizontal tail, pilots controlled pitch and roll with elevons on the trailing edge of the wing—control surfaces that have combined the functions of ailerons and elevators on all delta-wing airplanes right up through the Concorde. The Skyray's elevons were boosted hydraulically. Were the hydraulic system to fail, the stick could be extended about a foot to give the pilot enough leverage to move the control surfaces. Pitch trimmers augmented the elevons. Control in yaw was provided by a swept dorsal fin with an unboosted rudder.

Westinghouse had not yet delivered the J40 engine specified by the Navy, but with deadlines looming, Douglas jury-rigged the prototypes with Allison J35-A-17s, which left the airplanes sorely underpowered. In the fall of 1950, the prototypes were trucked to Edwards Air Force Base in California to see if they were more than just a pair of pretty faces.

First flight, and the harbinger of what the Chinese would call interesting times, came on the morning of January 21, 1951. Douglas test pilot Larry Peyton, whose experience was mainly in transports, was chosen for this run. The airplane was to be flown on manual controls to determine some of the nuances of takeoff trim. Then,

after some light maneuvering, back it would come to the lake bed. Piece of cake.

Peyton lifted off at 140 mph for what he intended to be a gradual climb to 10,000 feet. The Skyray had other ideas. As speed increased, so did nose-up pitch, even with the stick pressed against the instrument panel. When Peyton hit the trimmers, the nose pitched sharply down, and pulling the stick all the way back had no effect. Another try with the trimmers and the Skyray flared and mushed back to earth.

With the vast Edwards lake bed largely ahead of him, Peyton stayed with it, lifting off again. He brought the Ford into a steady climb at 160 mph—with the stick full forward. After a few test maneuvers, he turned for home and fluttered to the ground, fighting the weird pitch behavior. He never flew the Skyray again.

Another Douglas test pilot, Russell Thaw, took up the preliminary work of fixing the trim problems on takeoff. Then the Skyray passed to Robert Rahn, a top hand among the experimental test pilots. He had flown Spitfires with the Army Air Forces during World War II, and had since tested a host of aircraft types for Douglas.

Having seen Thaw's flights, Rahn was not sure he wanted to fly the XF4D, but in October 1951, he tried it on. "I flew on manual flight control and quickly learned why Larry wanted no part of the Skyray," he wrote in his memoir, *Tempting Fate*. "The stick forces were exorbitant for the small control-surface deflection achieved. The plane was tough to handle unless below 200 knots and in smooth air—not a good sign for a fighter which may have to make an approach onto the pitching deck of an aircraft carrier at night."

Still, the Skyray's potentially breathtaking performance, maneuverability at altitude, and the forgiving qualities of that huge wing found a spot in Rahn's affections. "This aircraft," he wrote, "was just what I had been looking for in a fighter since my flying days in the Spitfire. The F4D was a fighter pilot's dream." As Rahn would soon learn, it could also be a fighter pilot's nightmare.

"The Skyray," says Mal Abzug, "was the first Douglas airplane to have the phenomenon known as inertial coupling, in which the airplane goes out of control at high roll rates. It's caused by the way the weight is distributed. Ever since airplanes were made with the swept wings, they've all had that property. First airplane was the F-100. We had a problem about the same time, around 1950. The Skyray was one of the pioneering airplanes in this area."

And how.

Fighter aircraft are required to be able to enter and recover from spins, defined as uncontrolled rotations around any axis of a fully stalled airplane. Conventional recovery is a simple matter of applying opposite rudder to stop the rotation and moving the stick forward to get the nose down and restore airflow over the wing. The Skyray evidently thought this was too easy.

After preliminary spin tests with conventional recoveries, Bob Rahn took his prototype, now equipped with a non-afterburning but more powerful J40 engine, into the California skies to see how it performed with the center of gravity slightly aft, a change resulting from the installation of the new engine.

"I was down on the desert floor in the communications shack," Abzug recalls. "At 35,000 feet he kicked it over in a spin. There was a long silence. Then he finally said, 'Jesus Christ!' "

When he entered the spin at 35,000 feet,

Rahn had intended a couple of turns to the left, then recovery. Instead, he later wrote: "Spun one and a half turns then reversed direction, even as I held full pro-spin controls (full left rudder and full aft stick)." With the aircraft now in a slow, flat spin to the right, Rahn tried something else: He added left rudder against the spin and neutralized the stick. "The XF4D rolled abruptly upside down and started spinning inverted," Rahn reported. "I experienced severe oscillations in pitch as much as 120 degrees in a half turn and fell through the sky upside down. At this extreme attitude in pitch, I had the impression I was in a 60-degree, nose-down, upright spin."

Rahn deployed the spin recovery chute at 10,000 feet above sea level, just half a mile above the high desert floor, and the Skyray, having done its thing, resumed normal behavior. But he had been seriously spooked about spin testing the Ford.

Wind tunnel work indicated that Skyray pilots would have to unlearn what they thought they knew about spin recovery. In an upright spin, the pilot had to apply full opposite rudder, but also full aileron with the direction of spin. "I was the guy who briefed Rahn," says Abzug. "Ailerons with the spin: They were the predominant spin control. I had a hard time convincing him to do it." In the end, Rahn followed the new guidance and solved the problem, more or less. But the Ford never lost its reputation for unrecoverable spins.

When things worked well, however, they worked very well indeed. A year and a half into the Ford's testing—in mid-1952—a team of Navy and Marine pilots came to Edwards to evaluate the product. They noted its quirks but liked what they found at altitude, where the Skyray's big wing and inherent instability let it outturn anything then flying. Rahn wrote approvingly, "All of the Air Force chase airplanes fell out of the sky during these maneuvers."

Perhaps the highest praise came from Marine Major Marion Carl, one of the evaluating pilots, who said: "If we had this airplane now in Korea, I could just pop off the MiGs—one, two, three."

A month later Rahn put the cherry on top. The nominally supersonic Skyray had gone through 18 months of testing without reaching Mach 1, a milestone delayed by severe buffeting and the nose-down "tuck under" peculiar to swept-wing aircraft in the transonic region. (As aircraft approach Mach 1, shock waves begin to form in the airflow over the wings and the center of lift, the point at which the force acts on the wing, shifts aft. This shift causes the aircraft to pitch down. The Skyray was equipped with trimmers, in part to counter this effect.) After considerable tweaking, Rahn put his Ford into a shallow dive and at 30,000 feet pushed past the speed of sound—the first supersonic moment for a delta-wing airplane.

With this achievement, the Skyray was a natural to try for the world closed-course speed records, which had recently passed from the Air Force's F-86D to the Royal

Air Force's Hawker Hunter. After fitting an afterburner to the J40, the team ran enough trials to see how the Ford would handle with the added power. Lieutenant Commander James Verdin, a veteran Navy combat pilot, was set to try for the three-kilometer speed record, undaunted by the fact that it had just been broken again by a British Vickers Supermarine Swift in Libya going 737.3 mph.

On Saturday, October 3, after several failed attempts, Verdin's Skyray was streamlined, polished, stuffed with fuel pre-cooled for increased capacity, and ready for its final try. Verdin flew four passes 100 feet above the ground at an average speed of 752.9 mph—more than enough to strip the title from the British. Only eight minutes elapsed between the beginning of the first pass and the end of the fourth one, with the afterburner guzzling 3,450 pounds of fuel.

EDWARDS HISTORY OFFICE

**Shaving corners from the delta wings saved weight and gave the F4D its unique planform. Bob Rahn (above) tussled with the Skyray and others in the Douglas Sky series: -night, -raider, -hawk, and -warrior.**

OPPOSITE: EDWARDS HISTORY OFFICE

Two weeks later, Bob Rahn took on the 100-kilometer record at the Edwards course, a circle defined by 16 smoke pots and painted pylons. Flying 100 feet off the ground, Rahn flew straight lines to each pylon, rounding them with a brutally sharp, 70-degree bank. His average speed on the final, official run: 728.11 mph, a new world mark.

The Skyray—and Heinemann's design shop—entered a brief golden age. While Rahn and his colleagues had been wringing out one prototype at Edwards, Navy and Marine pilots had been growing the second prototype's sea legs at Naval Air Station Patuxent River in Maryland. The Skyray was headed for the fleet.

In mid-December 1953, the airplane's reputation was burnished further when Heinemann received the Collier Trophy for the Skyray; he shared the honor for the first supersonic fighter with North American's Dutch Kindelberger, father of the F-100 (and Heinemann's former boss). And there was more good news: Another Heinemann creation, the D-558-2 Skyrocket, made Scott Crossfield the first human to reach Mach 2 in an airplane and enabled Marion Carl to set an unofficial world altitude mark: 83,235 feet.

By this time no one believed Westinghouse could deliver a reliable afterburning J40. (Indeed, the J40 fiasco would drive the company out of the jet engine business.) But Heinemann had seen the problem coming, and had built the Ford's fuselage with enough space to accommodate a larger engine: Pratt & Whitney's afterburning J57-P-2, with 14,500 pounds of thrust. The Skyray would finally have enough power to serve as the interceptor that Douglas and the Navy had envisioned.

Production began in 1954. Once the F4D-1s were ready for flight testing, they were towed across Imperial Boulevard to Mines Field, now better known as Los Angeles International. The airplanes were supposed to include an Aero-13 fire control system, built around the Westinghouse An/APQ-50 radar, a system that could see targets 18 miles away and lock onto them at 12 miles. Like the J40 engine, however, the radars were slow in reaching Douglas, and not all Skyrays flew with that equipment; some spent their careers as day fighters, as their creators had intended.

The Ford's foibles remained, but were not seen as insurmountable. "It had a lot of complicated restrictions," says Abzug. "Get the thing rolling at high speed, you had to tell the pilot about restrictions. For example, at 400 knots do not exceed two-thirds aileron or one-third back stick. But there's no way pilots can remember all that stuff. We resorted to placarding," putting up the small warning signs that dot even Cessna cockpits with no-no's for the pilot.

On an afternoon in 1955, Bob Rahn leapt off the Los Angeles International Airport's runway in a production Skyray, heading out over the Pacific a hundred feet above the waves. The idea was to see whether enough pitch trim was available with the new engine to compensate for the airplane's tuck-under at transonic speeds. He later wrote, "I had accelerated to Mach .98 (approximately 750 mph) in afterburner. This Mach speed created the maximum tuck-under. Full trimmer deflection was required to maintain trimmed flight. Therefore I concluded that the engineers had done a good job with respect to adequate trim for this low-altitude, high-speed flight environment. For all practical purposes, the test was completed. So I nonchalantly shut off the afterburner."

The Skyray decelerated so rapidly that the trimmer became super-effective, flipping the nose suddenly skyward. "My Skyray and I were pitched up at a gut-wrenching 9.1 Gs," Rahn wrote. "The airplane had a design limit of 7.0 Gs. Moreover, I wasn't wearing a g-suit.... I immediately blacked out." Rahn lost his vision but was aware of his situation. Reluctant to touch anything for fear of making a bad situation worse, he endured the ride. When his eyes cleared, his windscreen was all blue Pacific. "I was in a vertical dive after completing three-fourths of a loop." Gingerly recovering at about 3,000 feet, he looked out at the wings. "They were wrinkled from wing tip to wing tip, resembling dried prunes."

Back on the ground at LAX, Rahn found that the rest of the Skyray's skin was wrinkled, the wings were incurably bent, and some of the vertical stabilizer's stringers were protruding, like broken bones. The engine had torn off its mounts and was resting on the engine-compartment access door, pinching a fuel line. Later, Rahn reckoned that the event had been caused by the added thrust and the resulting increase in tuck-under. The corresponding increase in nose-up trim had made the

**During the Cuban Missile Crisis, a VFAW-3 detachment took its Skyrays to Naval Air Station Key West, to guard against intruders crossing the narrow straits. "We were flying three, four times a night down there," says David Dungan. "No lights, just black water. Like flying off a carrier. No sooner were we airborne out of Key West, we could see the lights of Havana."**

Ford go nuts when it suddenly decelerated. Scratch one Skyray.

Even before the F4D entered production, the Navy had altered its mission. Instead of a day fighter, a role for which it had been exquisitely prepared, the Ford would now be an all-weather interceptor. Unstable and skittish by nature, the Skyray seemed a poor choice for such work, a thoroughbred tapped for hansom duty.

In April 1956, more than five years after the prototype's first flight, Douglas began delivering Skyrays. In all, Fords went out to 11 Navy, six Marine Corps, and three reserve squadrons, with a few more going to specialized units.

But the Ford's finest moment came not with the Navy, but with the Air Force.

The first unit to receive the Skyray, eventually reorganized as VFAW-3 (Fleet All Weather Squadron 3) and based at Naval Air Station North Island in San Diego, was the only Navy unit under the operational control of the North American Air Defense Command. It protected a southwestern wedge of U.S. airspace from unidentified intruders. Like Royal Air Force pilots during the Battle of Britain, the pilots of VFAW-3 slept in their flightsuits a short run from their aircraft.

"A claxon still makes the hairs stand up on my neck," says David Dungan, a retired Navy captain. "We'd come out of there like a shot. They held all traffic, airliners, everything, when we launched. From a sound sleep to takeoff on Runway 18 within five minutes. Flying out over the black sea. By the time we were in the airplanes we were so adrenalined up" all thought of sleep was gone.

"We were really good. One reason, we had only second-tour pilots, no one fresh out of training command. We all had some experience. The Air Force demanded that we be able to operate at 200-foot ceilings, half-mile visibility. You needed some experience."

"We did a lot of demo scrambles," remembers retired commander James Berry, another VFAW-3 veteran. "When VIPs came to North Island we'd get hit with

## SEE THE SKYRAY

**THE NATIONAL MUSEUM OF NAVAL AVIATION,** Naval Air Station Pensacola, Florida, exhibits an F4D-1 (#134806) in factory markings that flew in the test program at Naval Air Station Patuxent River between 1961 and 1966. **http://naval.aviation.museum/museum.html**

**THE PATUXENT RIVER NAVAL AIR MUSEUM,** Naval Air Station Patuxent River, Maryland has Skyray #134764 that served in Pax River's flight test division, in several squadrons, and at the U.S. Naval Test Pilot School, where it was a flying qualities demonstrator. **www.paxmuseum.com**


PIMA AIR AND SPACE MUSEUM

**THE PIMA AIR AND SPACE MUSEUM,** Tucson, Arizona, shows a Ford (#134748) used by the Raytheon Company to test and develop the Sparrow III air-to-air missile in 1961. **www.pimaair.org**

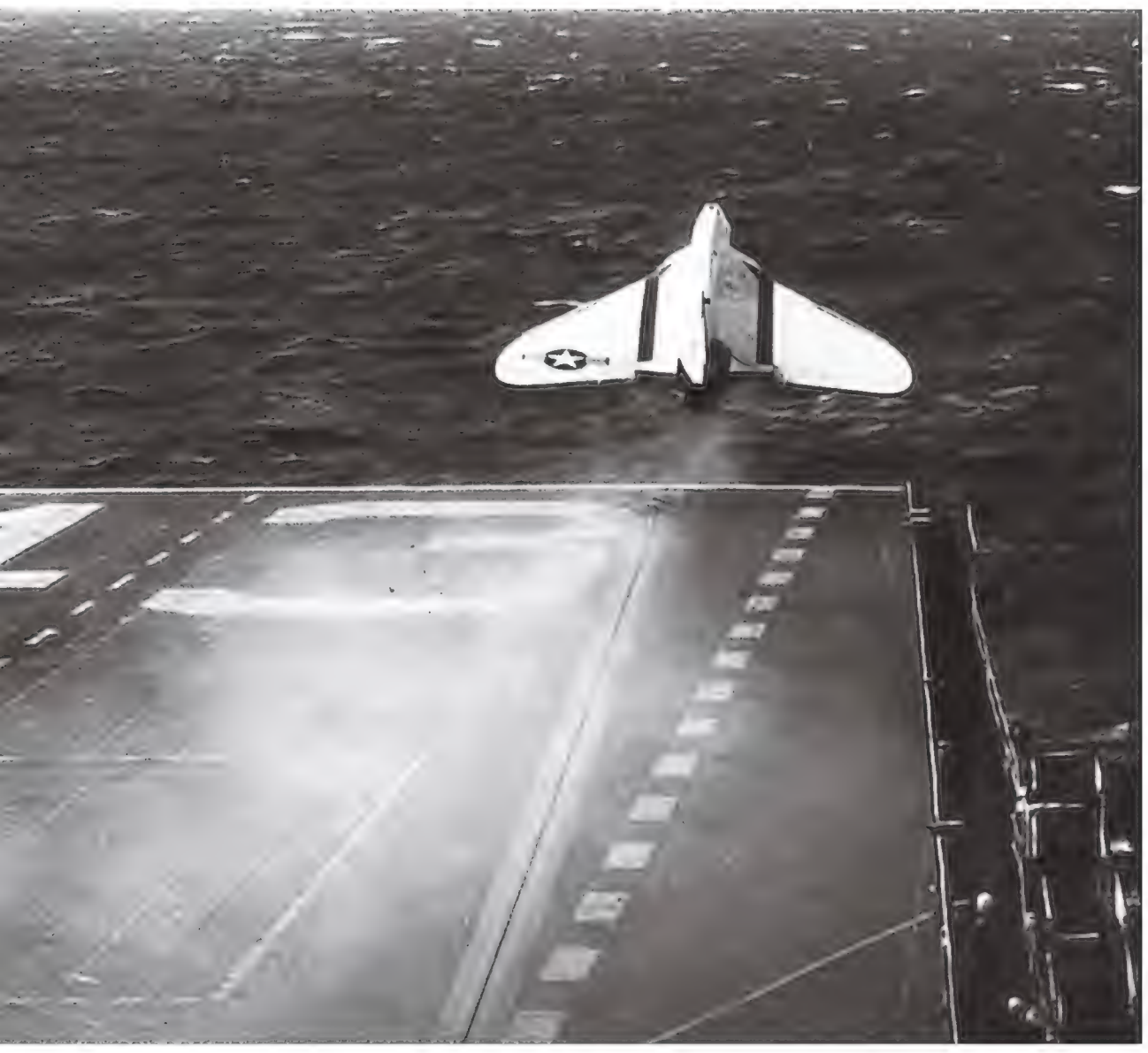
**The Skyray at the Pima Museum also served in Douglas and Navy test programs. All three aircraft bear the designation F-6A; the Skyray was redesignated in September 1962, by which time most were assigned to reserve units.**

the scramble horn. We had five minutes to get airborne. We were usually in the air with two aircraft in about two and a half minutes." Later he adds, "We were also sort of the apple of the Navy's eye, winning Air Force prizes."

Those prizes included the top interceptor titles in 1957 and 1958, flying against such faster Air Force fighters as the McDonnell F-101 and Convair's delta-wing F-102 and F-106.

were flying three, four times a night down there," says Dungan. "No lights, just black water. Like flying off a carrier. We had to intercept a lot of little planes." Private pilots would wander into defended airspace, causing the Skyrays to scramble. "No sooner were we airborne out of Key West," he says, "we could see the lights of Havana."

"There were a lot of problems with aircraft coming up from the south and flight plans not being passed through Cuba,"



NASM (SI NEG. #85-7251)

**Despite being too skittish for carrier ops, the F4D stayed at sea from 1956 to 1963.**

Dungan notes that in a fight, speed and better armament systems aren't everything. "We carried 2.75-inch FFAR [folding-fin aircraft rockets] in a pod. I think the Skyray would have done fine in combat. You have to use what you have. You didn't get into a merge fight with MiGs in the Phantom, you'd lose. The F4D, you could turn inside this room. There was also that acceleration."

During the Cuban Missile Crisis, a VFAW-3 detachment took its Skyrays to Naval Air Station Key West to guard against intruders crossing the narrow straits. "We says Berry. "We didn't make contact with any MiGs, but we were vectored toward them and they turned back for home."

As for piloting the Ford, "I loved it," says Dungan. "I didn't fly it onto a carrier, I flew it off the beach at North Island. It wasn't the most stable airplane in the world. You had to hold onto it on landing, that's for sure. The F4D rocked around a lot," partly because the main gear deployed one leg at a time, causing the airplane to skid. "We'd make an approach to North Island at 3,000 feet for Runway 27. About the time they turned us on final, we dropped the gear. The airplane would move around—it was like standing on top of a pencil. Okay in VFR conditions, but not so good in IFR approaches."

According to Gerald G. O'Rourke, a retired Navy captain with long experience in—and a low opinion of—the Ford, "The wings were large for the size of the plane, and altogether too efficient at producing lift at slow speeds. The vertical tail was too small and tended to get blanked out by the wings at the high angles of attack required for slower speed flight. As a result, the slightest disturbance induced by rough air or a rough pilot made the Ford swing from side to side on approach. As it did, the advancing wing increased its lift, the opposite one decreased its lift, and the plane started to roll.... Low-speed flight was really a series of wallowing, half-roll, half sideslip maneuvers that made the bird look drunk." He called the airplane the worst Dutch roller in the fleet.

Loved or loathed, the Skyray was on borrowed time. In December 1958 production had ceased at 420 airplanes, and orders for another 230 were canceled.

Ed LeFaivre's time-to-climb mark of May 1958 was snatched away that December by an Air Force F-104A. Bob Rahn's record-breaking 100-kilometer run was among the last flown so close to the ground. But in February 1959, a French Dassault Mirage III stole that crown, albeit at 22,970 feet. In August 1961, McDonnell's Phantom II broke Jim Verdin's three-kilometer mark. VFAW-3 was decommissioned in April 1963 and the Navy bowed out of the continental air defense system for good. The Marines' VMF(AW)-542, the last active-duty squadron to fly the Skyray, came home from Japan in November 1963. Even the phonetically evocative F4D designation disappeared, replaced by the F-6A tri-service nomenclature.

The oracles of aviation might have said that the end was discernible on May 27, 1958, just four days after LeFaivre became the fastest man to 50,000 feet. That was the date of the Phantom II's first flight. "As soon as the Phantom came in," says Erv Heald, "we were out of business."

Well, not entirely. Douglas tried to sell a new, improved Ford called the Skylancer, a longer, more powerful Skyray without the warts. The test pilots liked the new airplane, but the Navy chose Chance Vought's F8U Crusader. Because the Skylancer was never produced, the Ford earned one final distinction: It was Douglas' last fighter.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## SIGHTINGS

DESTINATION OSHKOSH! As photographer Max Haynes proves with his vintage lineup (left), aviation fans who travel to the Experimental Aircraft Association's annual July do in Wisconsin can see airplanes that created aviation's Golden Age. During that era, however, the airplanes traveled to the fans. Barnstorming began in the United States almost as soon as the airplane was invented, and in the 1920s, when retired Curtiss JN-4Ds were plentiful, became one of the country's most popular spectator sports. Once the flying circuses disappeared, individual pilot-entrepreneurs flew from town to town selling rides in Travel Airs and New Standards. And after World War II, pilots offered rides in retired military trainers like those at left—(front to back) Stearmans, Waco UPF-7s, and Ryan PT-22s.

This summer, airline pilot and modern barnstormer Clay Adams (below center) will revive the barnstorming of the Golden Age as well as entertain fans at Oshkosh. He has organized as many as 20 pilots to fly vintage airplanes to nine cities beginning on July 15 and ending in Oshkosh on July 26. For a tour schedule, visit *www.americanbarnstormerstour.com.*

Photographer Gilles Auliard, who has dedicated his career to photographing vintage aircraft, was on hand at the Antique Aircraft Association's annual gathering in Blakesburg, Iowa, last summer when Adams hatched the plan to create a barnstormers' tour. Auliard's air-to-air shots of Bob Newhouse's 1931 Bird (below left) and Adams' 1929 Travel Air (below right) create the illusion of a 1930s joyride through rural America. No wonder Adams was inspired to take the airplanes to the people again. "Surrounded by so much history," he says, "we wanted a way to share the stories of these planes and their pilots."

At Oshkosh, the barnstormers will conduct mini-forums near their aircraft. And of course there will be many more antique airplanes to see. "There's something about the vintage area that tends to draw you in," says Max Haynes. "After you're worn out from the rest of Oshkosh, it's the cozy spot."

# Secrets of Midway

## Shattered Sword: The Untold Story of the Battle of Midway

BY JONATHAN PARSHALL AND ANTHONY TULLY. POTOMAC BOOKS, 2005. 640 PP., $35.00.

THE BATTLE OF MIDWAY was one of the most important naval battles in history—a significantly outnumbered American force destroyed four of the six large fleet carriers of the Imperial Japanese Navy in World War II.

NASM (SI NEG. #90-4357)

**Four of these Douglas TBD Devastators launched from the USS *Enterprise* returned after the Battle of Midway.**


In *Shattered Sword*, Jonathan Parshall and Anthony Tully correct the many myths that have been perpetuated about this important battle, and address them through meticulous research and detailed reporting.

Parshall and Tully have set a new standard for researching, evaluating, and synthesizing material from sources around the world to provide a complete account of the Battle of Midway and the underlying causes of Japan's defeat.

Looking at several of the most controversial aspects of the Midway action reveals Parshall and Tully's meticulous search for truth. For instance, many authors decry Japanese Vice Admiral Chuichi Nagumo's failure to adequately search for American carriers, and believe the late launch of the cruiser Tone's No. 4 search aircraft responsible for failure to detect them earlier and strike first. *Shattered Sword* makes a compelling factual case that although the Japanese search was inadequate, the ironically late launch of the Tone 4 may in fact have accidentally accelerated the detection of the Americans. Similarly, it is widely held that lack of adequate Combat Air Patrol aircraft and their being "pulled to the deck" to repel the American Devastator torpedo-plane attacks enabled the successful Dauntless dive bomber attacks that sank the four carriers of the Japanese Mobile Force. Parshall and Tully demonstrate conclusively that the loss of those carriers was a result of Zero fighters being pulled laterally to the southwest, chasing the Devastators, that facilitated the American attack—and not their insufficient number or low altitude. At least 11 "urban myths" universally accepted by scholars and sailors have been shattered, providing a whole new level of understanding of the Battle of Midway.

Parshall and Tully have provided one of the most readable accounts of the Battle of Midway available anywhere. Though Shattered Sword concentrates primarily on the Japanese side of the battle, it includes enough about the American side to make it particularly balanced and useful. Experts will certainly agree that this is one of the two or three most important books on the Pacific War published in the last decade.

DOUGLAS V. SMITH IS A PROFESSOR OF STRATEGY AND POLICY AT THE U.S. NAVAL WAR COLLEGE IN RHODE ISLAND.

## Riding Rockets

BY MIKE MULLANE. SCRIBNER, 2006. 352 PP., $26.00.

MIKE MULLANE WAS one of the thousands of children whose parents took them outside in October 1957 to watch Earth's first artificial satellite cross the night sky. Sputnik sparked a lifelong passion in him, and a dream of someday flying in space. *Riding Rockets* is the story of his journey from satellite-watching kid to satellite-riding astronaut.

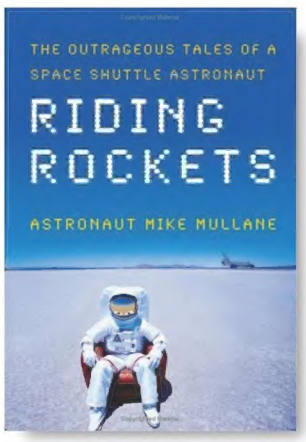
We first meet Mullane in a bathroom at NASA's Flight Medicine Clinic, where he is preparing to endure great indignities as part of a mandatory

physical examination. Told in trademark Mullane fashion, the story is laced with scatological comments that signal the start of a read that some will find hilariously ribald, others annoyingly adolescent. Caveat lector: Time spent reading *Riding Rockets* is exactly like time spent with Mullane in person, complete with his madcap storytelling style and invariably randy humor.

Mullane and I both joined NASA with the Class of '78. We were part of a group that broke the mold of prior astronaut selections in a number of ways: Most notably, ours was the first class to include women and minorities. What was it like on the ground when academics and test pilots, men and women, first met as peers within the astronaut corps? Mullane provides one man's view of the skepticism and scrutiny, the teasing and testing, the mutual give and take by which astronaut office culture and practice first reacted to these strange new creatures.

Near the end of *Riding Rockets*, Mullane laments that "political correctness" has overtaken the corps and is inhibiting the kind of great fun he recalls so fondly. Here I think he misses the larger point, namely that the culture has evolved since our day to better accommodate the many types of people who are now astronauts.

He does, however, list with pride some of the space firsts racked up by our class. Harsh though his first impressions may have been, Mullane clearly grew to appreciate the talents and courage of his classmates—even the "postdocs" and women. With *Riding Rockets* Mullane has added another first: He's the first from the Class of '78 to write about our times. And he's done it in rollicking good fashion.



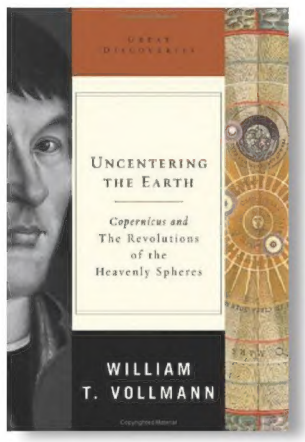

NASA ASTRONAUT KATHY SULLIVAN, SCIENCE ADVISOR AT OHIO'S CENTER OF SCIENCE & INDUSTRY, IS THE FIRST AMERICAN WOMAN TO WALK IN SPACE.

## Uncentering the Earth: Copernicus and The Revolutions of the Heavenly Spheres

BY WILLIAM T. VOLLMANN. ATLAS BOOKS/NORTON, 2006. 240 pp., $22.95.

"MUCH OF THE HISTORY of science consists in this: Observation slowly overcomes intuition," writes William T. Vollmann, grappling with the life, times, and legacy of Nicolaus Copernicus, in the most recent of Norton's Great Discoveries series.

Enamored as he was of Ptolemy's perfectly geometric universe of celestial spheres and fixed stars revolving around Earth, with Man at the center of all Creation, Copernicus still couldn't shake the problem that certain Ptolemaic calculations and predictions just couldn't be reconciled with Copernicus' own observations about "the appearances" of celestial movement. And while many of Copernicus' observations were later improved upon or discarded (Vollmann reminds us to be forgiving: The telescope wouldn't be invented until 1610, some 67 years after Copernicus died), by uncentering Earth in the grand scheme of our understanding, he dealt a crucial blow to the idea of a perfect and perfectly understandable universe.




The conceit of the Great Discoveries series is to turn excellent contemporary writers—non-scientists, mostly—loose on the stories of great moments in the history of scientific discovery. While *Uncentering the Earth* is certainly not a light read—Vollmann is known for his dense, difficult novels—the math and astronomy concepts from Copernicus' text are rendered with surprising clarity. More importantly, Vollmann brings his considerable talents as a storyteller to the tale of one remarkable book and "the struggle it represents to free the human mind from a false system."

COLIN BANE IS A FREELANCE WRITER AND PHOTOGRAPHER IN WASHINGTON, D.C.

## CALENDAR

**June 9-11**
***Bellanca-Champion Club West Coast Fly-In.*** Columbia, CA, (518) 731-6800.

**June 10 & 11**
***"Fly Iowa" Airshow and Fly-In.*** Northwest Iowa Regional Airport, Spencer, IA, (712) 262-1000.

**July 4**
***Taildraggers Fly-In.*** Shreveport North Airport, Wellsville, PA, (717) 432-4441.

**July 5-9**
***EAA Northwest Regional Fly-In.*** Arlington, WA, (360) 435-5857.

**July 14-16**
***"Gathering of Eagles" Airshow.*** Lost Nation Airport, Willoughby, OH, (440) 943-0084.



## CREDITS

**Cover.** John MacNeill works from a studio next to his house in western Massachusetts, where low-flying C-5s are a constant reminder of the acoustic strength of the U.S. Air Force.

**Operation Hot Wheels.** Allan T. Duffin is a squadron commander in the U.S. Air Force Reserve.

**The King Crab Caper.** An airport bum as a young man, Bruce Clemens is now a respectable college teacher.

**Cessna's Golden Oldie.** Roger A. Mola is a researcher at *Air & Space/ Smithsonian*.

**Superduperjumbo.** Michael Milstein is an environment and science reporter at the *Oregonian* in Portland.

**We Haul It All.** For John Croft, the Mil Mi-26 is like the Grand Canyon: Words cannot adequately describe its grandeur.

**How Things Work: Phased-Array Radar.** Sam Goldberg is a Tacoma, Washington-based freelance writer.

**The Beaver and the Swans.** A New York City resident, James Wynbrandt owns a Mooney M20K 252.

Clark Mishler lives in Alaska, where his air travel provides him with endless opportunities to take photographs.

**Take Two.** Tom LeCompte is a writer living in Cambridge, Massachusetts.

John Dibbs has photographed more than 850 air-to-air sorties.

**Glenn Curtiss Slept Here.** Phil Scott is the author of *Hemingway's Hurricane: The Great Florida Keys Storm of 1935*.

**Floaters.** Joe Pappalardo is an *Air & Space* associate editor.

**Beautiful Climber.** As a lowly tech writer at Douglas Long Beach in the late 1950s, Carl Posey sometimes envied the guys at Douglas El Segundo, where the Navy's legendary Skyrays, -warriors, and -hawks were being built.

## IN THE WINGS

### Farewell, Tomcat

When the F-14 retires this year, only *Air & Space* can get you behind the scenes of its entire career, from its first flight in 1970, to providing air cover for the evacuation of Saigon in 1975, to the Tomcat's last mission over Iraq in 2006.

ERIK HILDEBRANDT

**F-14s in formation, soon to be history.**

Also in the special section:

- Testimony from pilots, aircraft designers and maintainers who know the airplane best;
- First-hand accounts of the Tomcat's air duels during the Iran-Iraq war;
- An inside-the-wing description of how the F-14's distinctive variable-sweep system works;
- An examination of the cultural impact of the 1986 movie *Top Gun*, which propelled the Tomcat to international fame.

### Even Icons Need Assistants

Behind Norman Rockwell's famous paintings of the Apollo program is a young artist who helped his hero.

### Dust in the Machine

Lunar dust poses serious problems for moon exploration. Airlocks, anyone?

### Orbital Eyes on the Earth's Ice

As the argument over the causes and effects of climate change rage, a new breed of satellite brings much-needed facts to the debate.

# Iraq Air Force One

ON FEBRUARY 12, 2005, five U.S. Air Force Lockheed C-130 Hercules instructors flew a training mission tagged Train 60 with an all-Iraqi crew and, considering the nature of the mission, an unusual passenger manifest: the top officials of the newly formed interim Iraqi government, including prime minister Ayad Allawi and his deputy. The U.S. Advisory Support Team was charged with standing up Iraq's air force, and this group of former Iraqi pilots and crew, none of whom had flown in years, would be among the first to fly the transports that Iraq would soon operate. Says U.S. team leader Major Michael Frame, "They had flown Soviet-bloc aircraft, but that had been 10 years ago."

They took off from Ali Air Base, around which thousands of Coalition troops are based, destined for an unfinished commercial airport known as Al Sulaymania, near the northern city of Kirkuk.

Major Brian Lewis served as navigation instructor for the flight and would bring all his skills into play before the day was out.

As Frame heard Kirkuk radar inform Train 60 that it was leaving radar coverage, he also noted a cloud layer at about 6,000 feet. Because they were flying into rising terrain, the U.S. air crew made the decision to duck beneath the cloud layer and navigate to the airport visually. A lower altitude could have exposed them to enemy fire, but the decision itself was instructive to the Iraqi crew members, who will face such situations in the future.

Radio calls to the airport went unanswered, but the mission called for delivery of one prime minister, and that's what the team would provide. Train 60 made a low pass over the airport and spotted people and vehicles lined up along a taxiway. Two more low passes were made to ensure the landing could proceed, and, as planned, Frame took the controls on final approach and brought the C-130 in for a smooth landing.

For the mission, the U.S. Air Force and the National Aeronautic Association awarded the team of instructors aboard "Iraq Air Force One" the Mackay Trophy for the most meritorious flight of the year conducted by a member or members of the United States Air Force.

*—George C. Larson, Member, NAA*


MASTER SGT. MAURICE HESSEL/USAF

**An Iraqi Air Force C-130 gets a thumbs-up from a U.S. Air Force crew chief during a July 2005 mission from Ali Air Base.**

## LOGBOOK

**Thanks for the Memories**

Each year, the National Aeronautic Association selects from among the records set that year a list of Most Memorable Aviation Records.

Last April, a group of eight from 2005 were honored at NAA's Spring Awards Ceremony at the Ronald Reagan Washington National Airport in Arlington, Virginia.

Adventurer Steve Fossett set a new record for speed around the world, with his 67-hour, 2-minute, and 38-second flight in the Burt Rutan-designed Virgin Atlantic GlobalFlyer.

Troy Bradley, one of the world's most accomplished balloonists, set a new record for time aloft—a 46-hour, 50-minute February flight from Texas to Georgia. In November, 85 parachutists aligned themselves in a diamond formation over Lake Wales, Florida. Also that month, Suzanna Darcy-Hennemann and a team of Boeing pilots flew 13,422 miles in a 777-200LR.

John Parker broke a record in his Thunder Mustang for speed over a 15- to 25-kilometer straight course, flying 376.18 mph. Malcolm Stevenson set a distance record in ultralight gliders, flying 553.68 miles. Model aircraft builder and pilot Ken Jennings set a new record for radio-controlled electric-powered flight. He flew his model at 75.32 mph.

And in December, a new record was established for rocket engine aircraft by XCOR Aerospace's EZ-Rocket, flying 9.94 miles from Mojave to California City, California—the longest flight by any ground-launched rocket-powered airplane.

NAA National Aeronautic Association

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at *www.naa.aero* or call (703) 527-0226.